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ASSESSMENT OF CLOSED E. PAUZE LANDFILL SITE PHASE III INVESTIGATION AND MONITORING

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PHASE III INVESTIGATION AND MONITORING

Report prepared for:

Waste Management Branch
Ontario Ministry of the Environment

Report prepared by:

Terraqua Investigations Ltd.
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0.0 EXECUTIVE SUMMARY

Terraqua Investigations Ltd. was retained by the Ontario Ministry of the Environment to conduct an assessment of the groundwater conditions in the vicinity of the E.Pauze Landfill Site. . The scope of work included a review and assessment of historical analytical data collected between 1981 and 1990, performance of a field investigation in the area downgradient from the existing monitoring well network and a re-assessment of groundwater conditions based on the new field data.

The field work conducted included borehole drilling at three locations, installation of three monitoring wells, geophysical logging to assess subsurface geology and plume location, and groundwater sampling at the newly installed wells for analysis of landfill indicator parameters and volatile organic compounds. Data produced during the investigation enabled determination of the location and nature of the landfill plume at the leading edge.

Review of the entire suite of analytical data indicates that an elongated, narrow chemical plume, characterized by elevated inorganic solutes (i.e. chloride) and organic compounds (particularly phenols and toluene), is migrating from the Site within the main overburden aquifer. Toluene and phenols appear to be confined to the anaerobic core of the landfill plume, which is characterized by an elevated chemical oxygen demand.

September/August 1990 analytical data indicate the chloride ion plume has migrated approximately 1375 metres southwest of the landfill along a 1500 metre long flow path. Phenols and aromatic hydrocarbons such as toluene have migrated along a similar flow path as chloride ion, but lag behind chloride somewhat (1250 metres from landfill).

Other volatile organic compounds were identified in the downgradient groundwaters. A trichloroethene (TCE) plume is present in advance of the main landfill plume. Historical data indicate likely TCE sources both from the landfill site and from unconfirmed sources further downgradient from the landfill near an abandoned railway line and County Rd. 9. Mapping of the TCE plume indicates that it has been biodegraded by the advancing anaerobic landfill plume. This has resulted in the persistence of TCE in advance of the anaerobic landfill plume

and the progressive production of several other organic compounds from the biodegradation processes, such as vinyl chloride and chloroethane.

In general, then, it is expected that with continued plume migration, aromatic hydrocarbons such as toluene will migrate and persist as long as the landfill plume remains anaerobic. In time, the gradual decrease in the organic strength of the leachate from the site will allow for reversal to aerobic groundwater conditions and eventually lead to the degradation of toluene. The TCE plume, on the other hand, appears to be undergoing gradual biodegradation by the landfill plume. In front of the landfill plume, TCE would be expected to migrate and persist but also undergo some degradation and dilution to lower concentrations. These processes in effect are a form of passive remediation, whereby the aquifer itself provides the ability to assimilate the effects of the landfill. It is expected however, that this will be a slow process and will require that an effective and ongoing monitoring be undertaken.

Recommendations are made for a revised monitoring program including installation of additional monitoring wells beyond the present leading edge of the main landfill plume. This program will facilitate future tracking of the plume and investigate the TCE plume configuration in advance of the main plume. Yearly assessment of data is required to determine whether passive remediation is effective. The monitoring program must respond to the changes in groundwater impact.

1.0 INTRODUCTION

Terraqua Investigations Ltd. (Terraqua) was retained by the Ontario Ministry of the Environment (MOE) in April 1990 to conduct an assessment of the groundwater conditions in the vicinity of the closed E. Pauze Landfill Site (Site) near Midland, Ontario. This assessment is part of the MOE Waste Management Branch program entitled "The Assessment of Closed Waste Disposal Sites, Phase III – Investigation and Monitoring". The results of the assessment undertaken are presented in this report.

Background information related to the Site history, Site hydrogeologic conditions and previous work conducted is summarized in Section 2.0. Section 3.0 addresses the results of groundwater monitoring at the Site, as carried out by the MOE from 1984 to 1990 and previously by consultants on behalf of MOE and the Site owner. Sections 4.0 and 5.0 present, respectively, the results of the field investigation undertaken by Terraqua and an updated assessment of groundwater conditions based on the present monitoring results. Conclusions and recommendations from the present work are presented in Sections 6.0 and 7.0, respectively. Recommendations regarding future Site monitoring and additional investigative work are made.

2.0 BACKGROUND

2.1 SITE LOCATION

The E. Pauze Landfill Site (commonly referred to as the Pauze Landfill) is located approximately one kilometre southeast of the Village of Perkinsfield in Lot 12, Concession 9, Township of Tiny, Simcoe County. Figure 1 presents the Site location.

2.2 SITE HISTORY

The Site began receiving local domestic refuse in 1966 and, then, beginning in 1971 all domestic refuse from Tiny Township (including the municipalities of Midland and Penetanguishene) was disposed at the Site. Disposal of domestic refuse continued until the Site was closed in 1984. In addition to domestic refuse, solid and liquid industrial wastes from area industries and sewage sludge from the Midland Water Pollution Control Plant were disposed at the Site. Acceptance of these latter wastes ceased in 1980.

There were two other areas for disposal on the Site property, in addition to the landfill itself. These were a sewage lagoon (immediately north of the landfill area) and a liquid trench area (east of the landfill area adjacent to County Rd. 9). The liquid industrial wastes were disposed in the landfill and in the sewage lagoons as well as in the excavated trenches.

A MOE survey of liquid wastes received at the Site in 1979 indicated that a wide variety of industrial wastes, such as metal finishing wastes, organic solvents, resins, paints, pigments, waste oils, were disposed.

A more thorough examination of Site history is available in reports prepared by Gartner Lee Associates Limited (GLAL) and Morrison Beatty Limited (MBL).

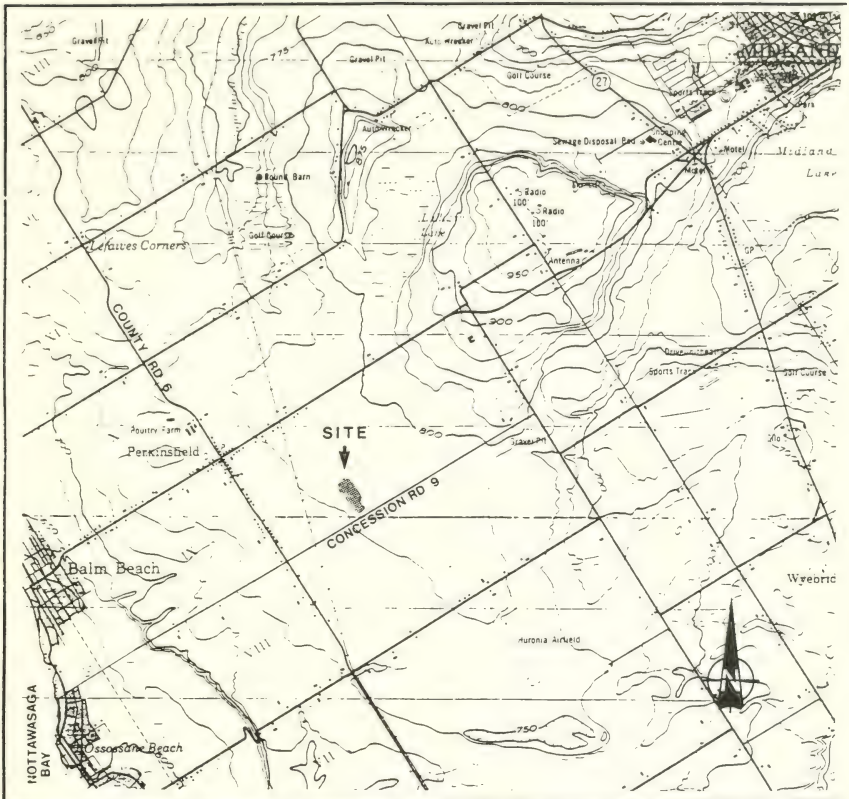


FIGURE 1 SITE LOCATION

SCALE 1:50,000

0 500 1000 2000m

PROJECT TA90228
MOE PHASE III
INVESTIGATION AND MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

LEGEND

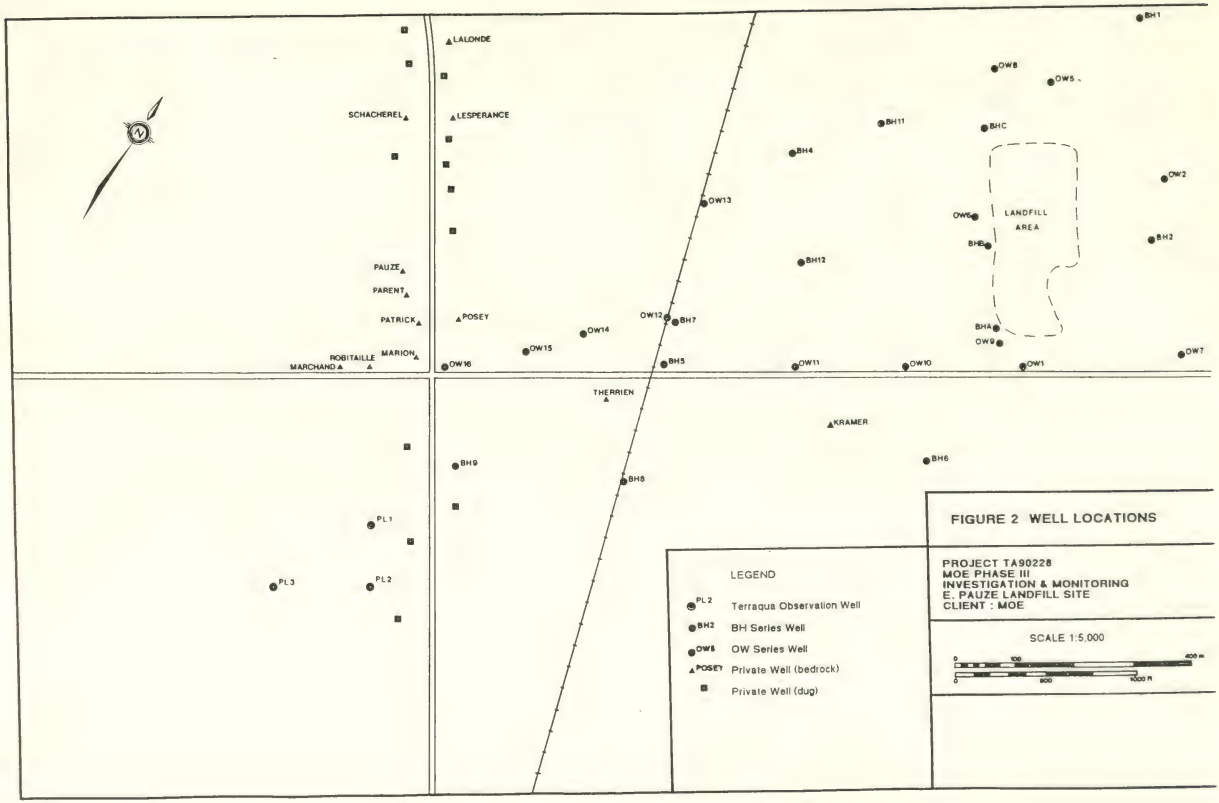
Site

2.3 PREVIOUS STUDIES

Several previous studies of the Site have been conducted. These include: the 1980 preliminary survey of industrial waste disposal sites for the MOE (GLAL), the 1981 hydrogeologic impact study of the Site for E. Pauze Construction Ltd. (MBL), the 1983 hydrogeologic study of the Site for the MOE (GLAL) and the 1984 monitoring data review for the MOE (GLAL).

During the 1981 and 1983 hydrogeologic studies, a total of fifty-nine (59) monitoring wells at twenty-seven (27) locations were installed to define hydrogeologic conditions and investigate landfill impact on the local groundwater. Figure 2 presents the location of the downgradient wells and most of the upgradient wells. Both studies identified a groundwater degradation plume containing typical landfill inorganic and organic contaminants to be emanating from the Site. The 1983 study by GLAL indicated the leading edge of the landfill plume had travelled on the order of 700 metres southwest of the Site. It was concluded that, under the calculated groundwater flow velocities of 70 metres/year and ascertained reduction processes, the plume would become indistinguishable from normal groundwater at about 1300 metres from the Site. Based on the 1984 review of new data and chemical trends, GLAL affirmed its prediction that the plume would become non-detectable about 1300 metres from the Site.

The 1981, 1983 and 1984 studies also identified several industrial organic compounds within the groundwaters downgradient from the Site. In particular, toluene (and to a lesser extent other aromatic hydrocarbons) was reported by GLAL to be emanating from the Site within the landfill plume. Also, both GLAL and MBL identified several chlorinated volatile organic compounds, in particular trichloroethylene (TCE) and 1,1,1-trichloroethane by GLAL and TCE, tetrachloroethylene, carbon tetrachloride and chloroform by MBL, to be present at some of the downgradient locations. Because of the particular locations that these parameters were found, it was concluded by MBL that the carbon tetrachloride and TCE presence were the result of isolated spill incidents along either County Rd. 9 or the railway line west of the Site. GLAL reached similar conclusions on the origin of TCE and 1,1,1-trichloroethane. Chloroform and tetrachloroethylene were attributed to solvent disposal in the southern part of the landfill.


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
ROBITAILLE
MARCHAND
MARION
POSEY
OW16
OW15
OW14
OW12
BH7
BH5
OW13
BH4
BH11
BH1
OW8
OW5
BHC
OW2
OW6
LANDFILL
AREA
BH3
BH2
BH12
BHA
OW9
OW11
OW10
OW1
OW7
THERRIEN
KRAMER
BH9
BH8
BH6
PL1
PL3
PL2
LEGEND
PL2 Terraqua Observation Well
BH2 BH Series Well
OW5 OW Series Well
POSEY Private Well (bedrock)
Private Well (dug)
FIGURE 2 WELL LOCATIONS
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 800 1000 ft

2.4 HYDROGEOLOGIC SETTING

The 1983 GLAL report specifically addressed the hydrogeologic setting beneath, immediately east and about 1000 metres southwest of the landfill Site. For a full description of the setting, reference to the GLAL report is advised. Only a brief overview is presented here.

The geology beneath the landfill and extending to about 1000 metres southwest of the landfill was identified to consist of an interlayered fine to coarse grained sand unit, ranging between 40 and 55 metres in thickness, underlain by a relatively impermeable till unit. It was interpreted that, up to about 900 metres downgradient from the Site, the sand unit is an unconfined aquifer, with a water table generally on the order of 10 metres below ground surface. Based on the results of drilling at a location (BH9) approximately 1000 metres southwest of the Site and examination of well records west of County Rd. 6, an upper silt till unit was interpreted to overlie the sand aquifer thereby confining the aquifer. The interpreted groundwater flow direction in the aquifer was generally southwesterly towards Nottawasaga Bay. In the westernmost part of the study area, where the majority of groundwater flow was anticipated to flow between the two till units, the total aquifer thickness was estimated to be on the order of 35 metres. The landfill plume had been identified in this aquifer.

2.5 GROUNDWATER MONITORING

Since 1983 a long term monitoring program has been undertaken by MOE to examine water quality trends and to assess plume migration. This program was carried out in accordance with the program recommended in the 1983 GLAL report.

The results of monitoring are addressed in Section 3.0.

3. REVIEW OF MONITORING RESULTS

Groundwater monitoring results are available from December 1981 (MBL), July/August 1983 (GLAL) and pseudo-quarterly from May 1984 to May 1990 (MOE). Only the "OW series" wells (MBL) were monitored in 1981 and only the "BH series" wells (GLAL) were sampled in 1983. A total of thirty-nine (39) selected monitoring wells at eighteen (18) locations were monitored from 1984 to 1990. Of these wells, ten (10) were monitored on a pseudo-monthly basis. In addition, several former private domestic supply wells, located downgradient from the Site, were monitored during the 1984 to 1990 sampling events.

The 1981 and 1983 reports contained reviews and assessments of the analytical data obtained from one single monitoring event carried out during the respective studies. These study results provide a "snapshot" of the groundwater conditions. The 1984 review provided a comparison of July 1984 data with July/August 1983 data to determine plume migration rates. Two data sets provide only the minimum amount of data required to project water quality trends and plume migration rates.

The large suite of data collected since 1984 has been amassed by MOE into a database of chemical results. This database contains selected general chemistry parameter and volatile organic compound (VOC) results from May 1984 to August 1988. A printout of this database, along with the 1981 and 1983 consultant reports and the individual laboratory result reports from September 1988 to May 1990, were provided to Terraqua for comprehensive review.

A review of the above data was undertaken during May to July 1990 by Terraqua. This was performed to ascertain the present configuration of the plume downgradient of the Site and so that the upcoming drilling program could be finalized. The objective of the drilling program was to provide additional spatial definition of the landfill plume at the furthest extremity (i.e. "at the leading edge") of the plume.

The subsequent sections describe the results of the comprehensive review undertaken.

3.1 GENERAL CHEMISTRY REVIEW

Seventeen (17) inorganic and organic indicator parameters have been included in the suite of analyses. An examination of the data from the various locations indicates that three (3) of these parameters, in particular, best define the configuration and chemical quality of the main plume emanating from the Site. These parameters are chloride, phenols and chemical oxygen demand (COD). Chloride ion is considered the most conservative parameter for mapping a landfill plume, because it is typically found in low concentrations in natural water, is generated from the biodegradation of many landfill materials, has a high solubility, does not significantly enter into chemical reactions and is reliably analysed in water samples. The plume of chloride therefore, can generally be considered the furthest extent of landfill impact. Phenols (total phenolic compounds) are often a good indicator of the organic strength of a landfill plume and in most groundwater environments, such as in the main aquifer at the Site, are not present naturally. COD is also a good indicator of plume strength. A high oxygen demand earmarks the core of a landfill plume, where anaerobic conditions prevail. This is important because many of the industrial organic chemicals identified in the groundwater downgradient from the Site behave differently in anaerobic and aerobic groundwater conditions.

Appendices A, B and C provide maps of concentration isopleths for selected monitoring events, for chloride, phenols and COD respectively. Graphs of chloride and phenols concentrations versus time for selected wells are also provided in Appendices A and B. Table 1 summarizes the appendices figure numbers corresponding to each event mapped and parameter graphed. Each parameter is discussed separately under the subsequent headings.

Chloride Ion

During the first few years of groundwater monitoring (refer to December 1981 and August 1983 isopleths), the chloride plume appeared to have reached about 700 metres from the Site. Migration was in a predominantly southwesterly direction and the most concentrated ion concentrations appeared to be emanating from the north central part of the landfill near locations OW6 and BHB (up to 630 mg/L). Background chloride concentrations appeared to

TABLE 1
SUMMARY OF CHEMICAL PARAMETER ISOPLETHS
IN APPENDICES A, B, C, D, AND E

Terraqua Investigations Ltd.
Project Number TA90228

Parameter	Event Mapped / Figure Number						
	Dec. 1981	Aug. 1983	Dec. 1984	Dec. 1986	Dec. 1988	Dec. 1989	Chemical Trend Graphs
Chloride Ion	A1	A2	A3	A4	A5	A6	A7 & A8
Phenols	B1	–	B2	B3	B4	B5	B6 & B7
Chemical Oxygen Demand (COD)	–	–	C1	C2	C3	C4	–
Toluene	–	D1	D2	D3	D4	D5	D6 & D7
Trichloroethylene (TCE)	E1	E2	E3	E4	E5	E6	–

be in the 'non-detect' to 5 mg/L range.

By December 1984 and December 1986 the "leading-edge" of the plume (Figures A3 and A4, Appendix A) had apparent migration distances of approximately 1000 and 1200 metres, respectively, from the landfill. At about 600 metres west of the landfill a gradual change in the plume migration direction from southwest to south had developed. The plume configuration by December 1986 was quite elongated (1200 metres) and narrow (from 400 metres at the Site tapering to about 250 metres at about 800 metres from the Site). Maximum chloride concentrations emanating from the landfill in 1986 had not changed considerably from those in 1981, but indicated higher concentrations emanating from the southern part of the landfill near location BHA.

The isopleth diagrams from December 1988 and December 1989 (Figures A5 and A6, Appendix A) indicate less apparent "leading-edge" advancement than in previous years. However, since the plume appears to have migrated well past location BH9 (the furthest downgradient monitor) plume definition at the "leading-edge" was poor. Also of note is the ceased monitoring of OW6 by 1988. It had historically been the best indicator of emanating chloride values. The apparent decrease in the advancement rate of the "leading-edge" during these years was accompanied by the widening of the plume (up to 350 metres at 1000 metres from the Site). This widening is best illustrated by the steadily increasing chloride concentrations at wells OW15d, OW16d and BH8-I.

The core of the plume has had a steadily increasing chloride concentration. Figure A7 (Appendix A) presents a graph of chloride concentrations versus time for selected locations (OW6s, BHA-III, OW12d and BH9-II) located along the apparent axis (centre line) of the plume. Notable observations from this graph include: OW6s had reported the highest concentrations traditionally but ceased to be monitored past November 1987; BHA-III results indicate a steadily increasing concentration trend until late 1987, then a steadily declining rate through to 1990; the steadily increasing concentrations reported for downgradient wells OW12d and BH9-II. The more recent decreases at BHA-III indicate that leachate generation in the southern part of the landfill may be lessening. Ceased monitoring at OW6s leaves unanswered whether leachate generation in the north-central part of the landfill has lessened.

It cannot, therefore, be concluded that the maximum chloride concentrations lie off site by 1989.

Figure A8 (Appendix A) presents a "blow-up" graph of the historical chloride concentrations reported for wells OW12s and BH9-II. Both well locations indicate increasing concentration trends of about 10 mg/L/year. The trends in chloride concentration, particularly those from well locations OW12s and BH9-II, will be discussed further in Section 5.4 (Plume Migration Rates).

Phenols

Although not included in the 1983 suite of analyses, phenols concentrations emanating from the north-central part of the landfill were steadily elevated during the December 1981 to mid-1985 time period (9,000 - 12,000 ug/L at OW6s). Prior to June 1985 no highly elevated phenols concentrations were reported to be emanating from the southern part of the landfill. Then, from June 1985 to late 1987, elevated phenols were reported at BHA-III (up to 9000 ug/L). Since these periods of elevated concentrations, levels have steadily declined at both locations indicating phenols concentrations in the leachate produced beneath the landfill has apparently lessened. These trends in phenols concentration at the landfill are well illustrated in the graph of historical data for OW6s and BHA-III (Figure B6, Appendix B).

Examination of the phenols isopleth from 1981 (Figure B1, Appendix B) indicates elevated phenols were present in areas other than at the landfill itself, such as near well locations OW1, OW3 and OW8. This may indicate phenols loading to the groundwater from the sewage sludge disposal area and liquid disposal trenches area. On the other hand, phenols are often detected in water samples collected from newly installed wells, attributed to introduction during drilling. Since wells OW1, OW3 and OW8 have not been monitored since 1981, the actual source of phenols at these locations is unknown.

Isopleth mapping in 1984 and 1986 (Figures B2 and B3, Appendix B) indicates a similar migratory path as evidenced with chloride ion, with a slight lag (time lapse) in the

advancement behind the more conservative chloride ion.

The 1988 and 1989 phenols isopleths (Figures B4 and B5, Appendix B) indicate an apparent large lateral advancement in the plume (up to 1150 metres from the Site by December 1989) occurred since 1986. Also notable from these latter two isopleths is the relatively narrow elongated nature of the plume in the furthest 600 metres.

Figure B7 (Appendix B) presents the historical phenols concentrations versus time for well locations OW12d and BH9-II. Phenols results reported for location OW12d indicate steadily elevated concentrations (generally 300-400 ug/L) reported from 1984 to the present. Location BH9-II, on the other hand, first had a phenols detection reported in mid-1986. From 1986 to late 1988 the phenols concentrations at this location increased slowly up to the 50 ug/L range. Beginning in late 1988 a larger increasing trend was reported, with concentrations reaching as high as 310 ug/L in early 1990. These significant increases in combination with the significant decreases observed near the landfill Site, indicate that a slug of phenol concentrated waters is migrating through the main aquifer.

Chemical Oxygen Demand (COD)

COD has been included as an analytical parameter since May 1984. Therefore, no information on the anaerobic/aerobic nature of the migrating plume from this particular parameter is available prior to 1984.

The December 1984 COD isopleth (Figure C1, Appendix C) indicates a highly anaerobic contaminant plume was emanating from the landfill, with a COD as high as 22,000 mg/L at location OW6s. The core of this plume (i.e. greater than the 500 mg/L range) had migrated to approximately 700 metres southwest of the landfill by December 1984.

The December 1986 isopleth (Figure C2, Appendix C) indicates a moderate advancement in the COD plume since 1984. A further and larger advancement, based predominantly on a large increase observed for BH9-II (from 60 mg/L to 890 mg/L), of the plume is indicated on

the December 1988 COD isopleth (Figure C3, Appendix C). Throughout this 1984 to 1988 period the COD concentration remained relatively constant (1000 mg/L range) in the core of the plume near wells BH7-II and OW12d. Closer to the landfill, the COD strength is not well defined because of the ceased monitoring of OW6s in November 1987.

The COD plume indicates a similar elongated, narrow plume configuration as indicated with chloride and phenols. However, the COD plume is generally narrower than the chloride plume. Chloride ion is more apt to exhibit lateral spreading compared to COD, which instead defines the inner anaerobic core of the landfill plume. Towards the outer edge of the plume aerobic conditions are expected to dominate. The centralized core of the landfill plume is well illustrated by the greater than 500 mg/L COD isopleth from December 1989 (Figure C4, Appendix C).

3.2 VOLATILE ORGANIC COMPOUNDS (VOC)

Examination of the VOC results from 1981 to 1990 indicates that several hydrocarbons are present in the groundwaters downgradient of the Site. These include aromatic hydrocarbons, in particular the BTEX fraction (Benzene, Toluene, Ethylbenzene and Xylenes), and several halogenated hydrocarbons such as trichloroethylene (TCE), 1,1,1-trichloroethane and 1,1-dichloroethane. The BTEX fraction were previously identified as emanating from the landfill, whereas the primary halogenated species were attributed in part to the landfill but primarily to undocumented possible spill or dumping incidents adjacent to Concession Road 9 and the railway line.

Of the identified compounds, two in particular typify the migration and behaviour of VOC in the groundwater downgradient of the Site. These are toluene, the aromatic found in highest concentration in the downgradient groundwater and most predictably mapped with the indicator parameters of the plume, and TCE, the most concentrated chlorinated VOC reported in the historical results although not necessarily directly a result of landfilling.

Toluene and TCE are also good choices for more in-depth examination because they behave

differently in the presence of anaerobic and aerobic groundwater conditions.

Toluene (C_7H_8) is used in many applications including as a solvent for paints, resins and as a gasoline additive. BTEX, and more specifically toluene, is expected to migrate more slowly than a more conservative dissolved inorganic ion, such as chloride, due to sorption by aquifer materials. The amount of sorption is a direct result of the amount of solid organic matter present in the aquifer. The BTEX fraction can also more readily biodegrade in the presence of oxygen in the aquifer. For these reasons, toluene persistence is controlled mainly by biodegradation and toluene mobility is limited by sorption effects. It follows that, in an anaerobic (oxygen depleted) groundwater environment with insufficient solid organic matter to retard migration, toluene would be expected to both migrate and persist.

TCE (C_2HCl_3), on the other hand, behaves quite differently in a groundwater environment than an aromatic hydrocarbon. It is a very common solvent for paints, oils, resins, waxes, etc., and is predominantly used as a degreasing agent and in the dry cleaning process. TCE can be degraded biologically in an anaerobic groundwater environment such as in the landfill plume emanating from the Site, however, is quite persistent in an aerobic environment such as to the edge of and in front of the landfill plume. Mobility of TCE is also controlled to a great degree by sorption onto solid organic matter in an aquifer.

Most halogenated and aromatic hydrocarbons would be expected to be relatively mobile in the main aquifer downgradient of the Site because the aquifer appears to be predominantly sand and contain little fines (associated with solid organic matter).

It follows from the above discussion, that a high COD, which signifies the anaerobic nature of the landfill plume, would be a prime potential location to find toluene rather than TCE, if both were present in the source area. A halogenated organic such as TCE, if present outside of the anaerobic landfill plume, would be expected to persist and migrate with the existing flow system.

Historical monitoring results of the two target compounds described above are addressed under the subsequent headings.

Toluene

August 1983 monitoring results (Figure D1, Appendix D) indicate a relatively low concentration plume of toluene was emanating from the landfill, following the same flow path as the plume of general indicator parameters. The maximum toluene concentration is not known from the 1983 data because well OW6s (typically having the most elevated parameter results) was not sampled. The December 1984 results (Figure D2, Appendix D), on the other hand, illustrate the elevated toluene levels emanating from the north central part of the Site (1670 ug/L at OW6s).

The toluene plume diagrams from 1984 to 1988 indicate the advancement of the plume along the same southwesterly flow path as other parameters mapped. In addition, as with the other parameters mapped, the leading edge of the toluene plume did not appear to migrate longitudinally from December 1988 to December 1989 to any significant degree.

Lateral spreading of the toluene plume appears limited and is controlled by the lateral spreading of the anaerobic core of the plume, as indicated by the COD.

Trends in toluene concentration for selected wells along the plume axis are presented on Figure D6, Appendix D. Results from wells OW6s and BHA-III (both shallow wells) indicate an erratic toluene loading from the landfill, with the highest concentrations emanating during the period from early 1986 to mid-1988. As indicated previously, the ceased monitoring of OW6s in 1987, raises a question about the leachate strength (and toluene concentration) emanating from the north-central part of the landfill since 1987. Chemical trends from BHA-III data indicate a virtual cessation of toluene emanating from the southern part of the landfill.

Figure D7 (Appendix D) presents a "blow-up" graph of the historical results from the two wells (OW12d and BH9-II) located along the plume axis furthest from the site. The toluene concentration trends for these two locations indicate very similar trends as the concentration trends for phenols. Well OW12d results are rather erratic but generally range between 100 and 500 ug/L throughout the historical record. Well BH9-II, on the other hand, first had a toluene detection reported in March 1986. As with phenols at this location, toluene

concentrations have increased considerably since late 1987, with the 1990 results in excess of the 200 ug/L level.

Since toluene presence and trends appear to be quite similar to that of phenols (with the exception of an established decreasing concentration trend at OW6s), it is possible that the majority of toluene within the landfill plume now lies off Site. However, since a decreasing concentration trend for OW6s has not been established (as it has at BHA-III) this interpretation can not be confirmed.

Trichloroethylene (TCE)

TCE has been a much discussed organic compound in relation to this Site. Acceptance of solvents, such as TCE, at the Site ceased in 1980. It would be expected that a solvent like TCE, if disposed at the Site in the non-aqueous form, would travel to depth quite quickly given the geologic setting of the Site.

The 1981 groundwater monitoring included only the OW-series wells, which are installed either at the water table or up to approximately 10 metres below the water table. December 1981 results (Figure E1, Appendix E) indicate TCE presence at four (4) monitoring locations (OW1, OW9, OW10 and OW11) along Concession Road 9 adjacent to the landfill. At two of these locations (OW9 and OW11) TCE was reported for both the shallow water table well and the deeper well. At both locations the higher concentration was reported for the deeper well (ie. OW9d and OW11d). Two other monitoring locations (OW12 and OW13) along the abandoned railway line west of the Site had TCE reported in both the shallow and deeper zone wells. The higher concentration in the case of location OW12 was reported for the water table well, OW12s. The presence of TCE at these locations raises the possibility of accidental spillage or illegal dumping along both the abandoned railway line and Concession Road 9.

In addition to the above mentioned locations, TCE was reported at OW5s and OW5d, indicating possible emanation from the sewage sludge disposal area. Well OW6s, located directly downgradient of the landfill, was not sampled in 1981.

The August 1983 monitoring results (Figure E2, Appendix E), which did not include any of the OW-series wells, indicate a low concentration of TCE present directly downgradient from the landfill (at locations BHA-III and BHB-III) and higher concentrations at downgradient locations BH5-III, BH8-I and BH9-II. The presence in the shallow zone at BH5 is likely a result of past spillage adjacent to either Concession Rd. 9 or the railway line. The presence of TCE in the deeper zone of the main aquifer at locations BH8 and BH9 is likely the result of migration from the upgradient sources identified in 1981. BH8 is outside of the flow path of the indicator parameter plume from the Site, therefore, the presence of TCE here is likely a result of the potential source areas south of the landfill (ie. near OW1, OW9, OW10 and OW11).

Subsequent monitoring at the Site did not include four of the wells (OW1, OW5, OW9 and OW13) in which TCE was reported in 1981. Because of this lack of possible key data, isopleth mapping for subsequent years may not present a complete picture of TCE presence and migration patterns.

Figure E3 (Appendix E) presents the December 1984 TCE data and interpreted isopleths. Of note from this data set is the elevated concentration reported for OW6s (143 ug/L), indicating that TCE is emanating from the north-central part of the landfill. The most elevated TCE concentration reported in the December 1984 data set was that for OW11s (1340 ug/L), likely the result of local spillage or dumping. TCE was identified downgradient of this location at OW15d, OW16d, BH9-II and BH8-I. Mapping of the apparent plume configuration indicates a far wider plume of TCE and further migration than any other related parameter. The width can likely be attributed to the multiple sources (ie. north-central part of landfill, south of landfill near OW1 and OW9, railway near OW13 and roadside near BH5 and OW11). Note, however, that with the lack of 1984 data from location OW13, the isopleth map depicts the upgradient part of the plume width to be somewhat less wide. The early longitudinal extent of the plume is likely the result of the source areas being located up to 700 metres west and downgradient of the Site. In addition, if TCE was present in non-aqueous form where it was spilled or disposed at the Site, it would likely travel quite quickly towards the water table, possibly well in advance of other landfill indicators.

December 1986 mapping of TCE concentrations (Figure E4) indicates a similar migration

pattern as depicted with the December 1984 data, but with a notable increase in reported concentrations towards the edge of the TCE plume (ie. at BH8-I, OW15d and OW16d). This may be the result of the separate source areas. Intermediate to the December 1984 and December 1986 'snapshots', maximum reported TCE concentrations at the two primary TCE source areas were 1830 ug/L (OW11s, Sept 1985) and 720 ug/L (OW6s, July 1986).

The December 1988 and December 1989 isopleth maps (Figures E5 and E6, Appendix E) show a significant change in the distribution pattern of TCE. One of the two main source area wells, OW6s, was not sampled, while the other, OW11s, had reported a much reduced concentration (21 ug/L, December 1988). Although OW6s has not been sampled since November 1987, results from the four monitoring events in 1987 were all 'non-detect' and indicate that TCE is likely no longer present in the shallow groundwater emanating from the north-central part of the Site. Other reported concentrations from the December 1988 event are greatly reduced with no detection at all for BH9-II, the furthest downgradient location. No detectable concentrations of TCE were reported from the December 1989 event, nor for any of the monthly monitoring events carried out since (January, March, April and May 1990).

A possible explanation for the evolution of the TCE plume to virtual non existence in the main aquifer (at least up to 1000 metres from the Site), lies in an understanding of the behaviour of TCE in the presence of aerobic and anaerobic groundwaters. As discussed in the preface to this section, TCE would be expected to biodegrade in an oxygen deficient groundwater environment, such as the anaerobic landfill plume emanating from the Site, while persist and migrate in the aerobic part of the main aquifer (ie. in front of and at the edges of the landfill plume). It follows that, since TCE appeared to have migrated well in front of the anaerobic landfill plume it persisted and travelled beyond the furthest well monitor (BH9). However, as the landfill plume expanded and migrated the anaerobic nature of the plume caused biological degradation of the TCE, at least within the plume core. At locations such as OW16 and BH8, where only the fringe of the landfill plume had reached by 1989 but where TCE had been found historically, it is expected that TCE in groundwater would not have undergone degradation processes. Rather, it is expected that the degradation of the upgradient source areas have caused groundwaters flowing by these areas to be devoid of TCE. Based on historical patterns it is quite possible that TCE persists in front of the landfill plume.

4.0 FIELD INVESTIGATION RESULTS

Pursuant to carrying out the comprehensive review of historical monitoring results, an investigation of hydrogeologic conditions downgradient of the existing network of monitoring wells was undertaken. This was necessary to assess the extent of landfill (or other) impact beyond the existing wells.

The investigation was conducted during July to September 1990 by Terraqua with components of the work performed by subcontractors under Terraqua supervision or direction. These included: borehole drilling / well installation by All Terrain Drilling Ltd., geophysical logging by Hyd-Eng Geophysics Inc. and laboratory analyses by Enviroclean. Results of the various field activities are summarized in the subsequent sections. Groundwater sample analyses are discussed separately in Section 5.0.

4.1 BOREHOLE DRILLING / MONITORING WELL INSTALLATION

4.1.1 Methods

Three prospective locations were selected, in consultation with MOE, for possible drilling and installation of three monitoring wells. These locations were situated on private properties, owned by Messrs. Senchyna and Desroches, east of County Road 6. Permission for well installation and future well monitoring was secured from each property owner prior to drilling. Although three locations were selected, it was possible that only two locations would be drilled, with one of the locations having two wells (ie. nested). This would depend on the results of geophysical logging at the first two locations.

Drilling was performed using the mud rotary method with a track mounted CME 75 drill rig. This method was selected because of the expected deep drilling in saturated sands. Subsurface materials were sampled in two ways, firstly via careful sifting and examination of the drill cuttings brought to the surface with the circulated drilling mud and secondly by split-spoon sampling at selected depths. The split spoon samples were collected at locations

where subsurface geology had been determined (from cuttings and drilling pressure) to have changed.

Monitoring wells were constructed of 5.08 cm (2 inch) diameter PVC number 10 slot well screen and 5.08 cm (2 inch) diameter flush threaded solid PVC pipe for risers and sumps. Graded silica sand was placed around the slotted well screens while the remainder of the borehole annulus (both below and above the screened intervals) were filled with bentonite hole plug and/or grout to prohibit a hydraulic connection between the screened intervals along the filled boreholes. Each well was completed with an above ground lockable protective casing.

After well installations were completed, a level survey was completed to establish the top of casing and ground surface elevations. The top of casing elevation for BH9-III was used as a bench mark elevation for the survey. Locations were 'tied-in' by chaining distances to known surface features such as houses and roads. The location of the BH9 well nest was determined to be approximately 50 metres further south than had been presented in previous reports.

4.1.2 Drilling / Installation Results

Appendix F provides borehole / well logs for the three locations drilled in the current program. For reasons discussed in this section all three wells installed were single wells (ie. not nested). Table 2 provides an elevation summary of the stratigraphic contacts encountered at each borehole location and Table 3 presents information on the monitoring well installation depths and water elevation monitoring.

Borehole drilling commenced on July 26, 1990 at location PL1 (refer to Figure 2), located on the Senchyna property. This location appeared, from the preliminary mapping of the landfill plume, to be located along the axis of the landfill plume approximately 230 metres southwest of the apparent BH9 location. Drilling continued to a depth of approximately 38.7 metres (127 feet) below ground surface, with the final 9.7 metres consisting of silt till. Above the silt till an approximately 15.3 metre unit was encountered, comprised of saturated silty fine

TABLE 2
SUMMARY OF BOREHOLE STRATIGRAPHY

Terraqua Investigations Ltd.
Project Number TA90228

BOREHOLE ID	GROUND SURFACE ELEVATION (mAMSL)	TOP OF UPPER SILT UNIT ELEVATION (mAMSL)	UPPER SILT/ SAND UNIT INTERFACE ELEVATION (mAMSL)	SAND UNIT/ SILT TILL UNIT INTERFACE ELEVATION (mAMSL)	POTENTIOMETRIC ELEVATION (LOWER ZONE SAND AQUIFER) (mAMSL)	SAND AQUIFER THICKNESS (metres)
PL1	230.24	225.67	216.52	201.28	218.34	15.24
PL2	230.32	224.22	217.67	202.89	216.85	14.78
PL3	229.67	225.65	214.43	201.17	215.08	13.26

Notes:

1) All Stratigraphic elevations are approximate, based on interpretation of drilling conditions, drill cuttings and split spoon samples

2) Ground Surface elevations surveyed on August 15, 1990

3) Piezometric Elevations (as measured on Sept 5, 1990)

TABLE 3
SUMMARY OF MONITORING WELL
INSTALLATION DETAILS AND WATER LEVELS

Terraqua Investigations Ltd.
Project Number TA90228

WELL ID	TOP OF CASING ELEVATION (mAMSL)	GROUND SURFACE ELEVATION (mAMSL)	SCREENED INTERVAL		TOTAL WELL DEPTH (OF SUMP) (metres)	STATIC WATER LEVEL (mAMSL)		
			ELEVATION RANGE (mAMSL)	DEPTH OF SCREEN TIP (metres)		Sept/86	Aug 15/90	Sept 5/90
BH9 – I (Deep)	232.68	232.22	188.02 – 189.52	44.2	..	222.91	221.22	221.18
BH9 – II (Int)	232.71	232.22	200.22 – 201.72	32.0	–	221.74	219.98	219.94
BH9 – III (Shallow)	232.72	232.22	211.82 – 213.32	20.4	–	221.80	220.16	220.14
PL1	231.14	230.24	201.28 – 204.33	28.96	38.10	–	218.37	218.34
PL2	231.19	230.32	207.31 – 211.88	23.01	27.58	–	216.87	216.85
PL3	230.32	229.67	201.17 – 205.74	28.50	30.48	–	215.08	215.08

Notes: 1) Sept. 86 Water Levels by MOE

sand with some medium to coarse sand seams (predominantly in the lower zone), which in turn was overlain by a silt to clayey silt unit (about 9.1 metres thick). Fine sand and silt layers were found in the upper 4.6 metres of the borehole. The saturated sand unit was interpreted to be the main aquifer which underlies the general study area.

A 3 metre (10 foot) long well screen was placed in the bottom portion of the sand aquifer, with a length of solid PVC pipe placed beneath the well screen (ie. 'a sump'). Placement of the sump would allow future geophysical logging of the borehole to below the apparent aquifer/till contact. Pending the results of geophysical logging of this borehole, a second well (one of the three to be installed) may have been required at this location to screen the vertical centre or core of the plume.

In the interim, borehole drilling commenced at location PL2 (Figure 2) on the Desroches property (approximately 110 metres southeast of PL1). Drilling was conducted to approximately 31.1 metres (102 feet) below ground surface at PL2. The final 7.2 metres consisted of a silt till unit, generally similar to that found at PL1, but with some sandy till in the upper portion of the unit. The sand aquifer encountered above the till, was approximately 14.8 metres thick and was fine to medium grained. The aquifer was in turn overlain by a silt unit (approximately 6.2 metres thick) and fine sand and silt layers to the surface. A 4.5 metre (15 foot) long well screen was placed in the bottom portion of the sand aquifer, with a length of solid PVC pipe placed beneath the well screen (ie. 'a sump'). As at location PL1, placement of the sump would allow future geophysical logging of the borehole to below the apparent aquifer/till contact. However, difficulties arising during installation did not allow placement of the sump to the borehole bottom, as at PL1.

While drilling and installation was being conducted at PL2, the completed installation at PL1 was being logged for apparent conductivity and natural gamma. Results of the geophysical logging at PL1 and other wells logged are discussed in more detail in Section 4.2. Results of the logging at PL1 indicated the presence of an anomalous conductivity zone in the bottom 6 metres of the sand aquifer. It was assumed that this anomaly corresponded to the central part of the landfill plume. Since the well screen had been installed in the centre of the anomalous zone it was decided that a second well at this location was not necessary.

Geophysical logging results at PL2 also indicated the presence of an anomalously high conductivity zone in the bottom zone of the aquifer. The PL2 well screen had also been placed in the central part of the apparent anomaly and, therefore, it was decided a second well at this location would not be necessary. Pursuant to the geophysical results at PL1 and PL2, the third prospective location was selected for drilling and installation of the third well.

PL3 is located on the Desroches property approximately 1350 metres southwest of the landfill and approximately 200 metres south of PL1. Drilling was performed to approximately 31 metres (102 feet) below ground surface, the final 2.6 metres consisting of silt till. This till was overlain by similar geologic materials (silty fine sand aquifer overlain by silt) as found at PL1, with the absence of the medium and coarse grained zones at the bottom of the aquifer unit. The aquifer thickness at this location was approximately 13.3 metres. A 4.5 metre well screen was installed in the lower zone of the sand aquifer, under the assumption that the migrating landfill plume, if present at this location at all, would likely be present in highest concentration in the bottom zone, as at PL1 and PL2.

Installation of PL3 on August 2, 1990 completed the drilling program.

4.2 GEOPHYSICAL LOGGING

Geophysical logging was performed on July 31, 1990 on boreholes PL1, PL2 and BH9-I, as stated previously. Logging of these boreholes was not originally part of the proposed scope of work, but was recommended by Terraqua to provide an indication of the vertical location of the landfill plume. MOE approved with the undertaking of this additional work. The rationale for performing the geophysical logging was as follows: if, after logging the first hole (PL1), a higher conductivity zone was encountered above the installed well screen, then a second well screen would have been installed to the depth of the apparent plume core. PL2 was logged with a similar intention. PL3 was not logged, as this was beyond the scope of the supplemental work recommended.

Appendix G provides a copy of the report prepared by Hyd-Eng Geophysics Inc. Reference

should be made to this letter report for a full explanation of the logging results.

Two geophysical logs were carried out on PL1 and PL2, the EM 39 (electromagnetic) apparent conductivity log and the natural gamma log. The gamma log provides a measure of the natural gamma energy emitted from the subsurface materials. This is generally a measure of the clay content (which emits more natural radiation than coarser grained silica rich materials) in a soil material. This information can be used to assess types of subsurface materials. The apparent conductivity log measures conductivity in the surrounding geologic material and identifies anomalously high conductivity zones. The conductivity information was the focus of the geophysical work undertaken, because it can provide good information on the location of a groundwater zone with high dissolved ionic species, particularly dissolved salts such as chloride ion.

The results of the logging of PL1 and PL2 were positive. It provided confirmatory information on the sand aquifer / silt till unit contact and the location, depth range and magnitude of an anomalous conductivity zone at the base of the aquifer.

BH9 logging consisted of the gamma log only, because steel well casing had been installed, thereby precluding the use of the conductivity log. Little information was produced from this log.

4.3 WELL RESPONSE TESTING

Prior to conducting well response tests each of the installed wells was developed on August 15, 1990 by purging a minimum of ten well volumes of water and monitoring for conductivity. Stabilized conductivities were measured after 5 or 6 well volumes of water had been removed. Development was performed using a WaTerra Power Pump, with 1.25 cm (0.5 inch) diameter plastic tubing and a foot valve. Each well was facilitated with dedicated plastic tubing prior to development, to avoid the possibility of cross-contaminating the wells with sampling equipment. These tubing / foot valve setups have been left in the well casings.

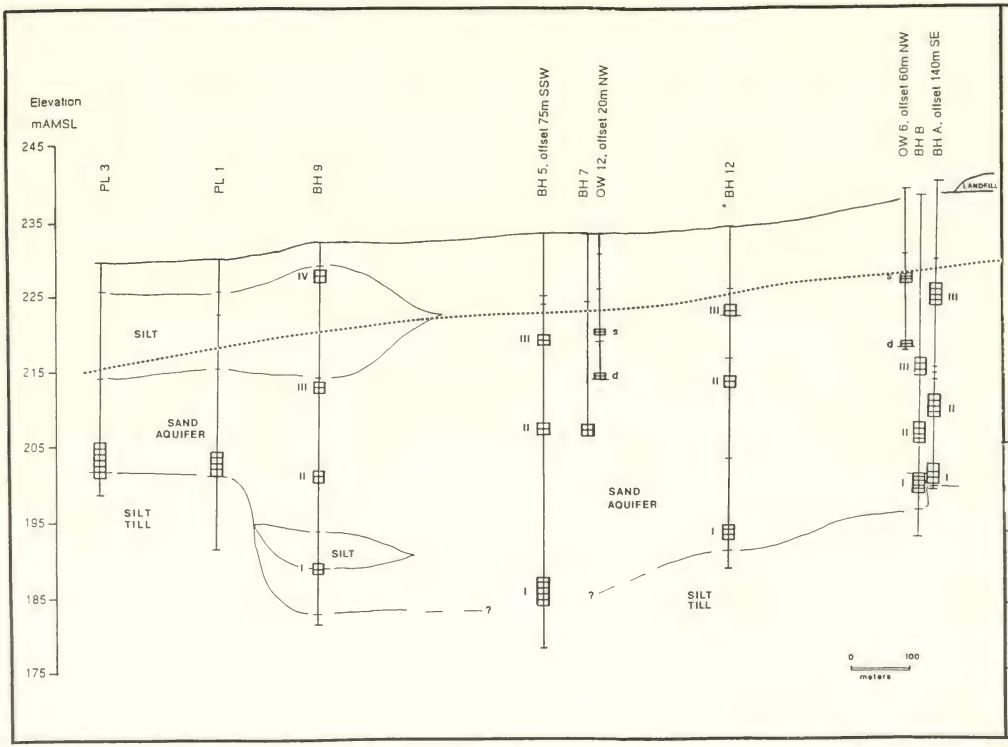
Single well response tests were performed on each of the wells on September 5, by purging water from the wells with the WaTerra system and monitoring the water level recovery over time. Graphs of the test results are presented in Appendix H. Knowing the construction dimensions of each well and using the test data, a computer program was used to calculate the corresponding estimate of hydraulic conductivity.

Results indicate hydraulic conductivities of 1×10^{-2}, 3.7×10^{-3} and 1.2×10^{-3} cm/s, respectively for PL1, PL2 and PL3. The higher conductivity for PL1 is indicative of the coarse grained sand seams found at the depth of the well screen at this location. The geologic materials at the PL2 and PL3 screened zones consisted of fine sand (with some medium) and silty fine sand, respectively. These estimates of the aquifer hydraulic conductivity can be utilized to calculate groundwater flow velocities in the aquifer.

4.4 UPDATE TO DOWNGRADIENT HYDROSTRATIGRAPHY

Figure 3 presents a geologic cross-section (A-A') from the landfill Site to the present study area, through boreholes BH8, BH12, BH7, BH9, PL1 and PL3. The relative location of offset boreholes BH4, OW6, OW12 and BH5 are also presented on the section. Figure 4 shows the location of the cross section. The cross-section presents only the generalized hydrostratigraphic units interpreted from the borehole information. The sand aquifer / silt till unit contact for the area from the landfill to BH9 has been transcribed from the 1983 GLAL report, with no attempt to reassess geologic data. Figure 4 also presents the potentiometric surface of the intermediate zone of the main aquifer. Water elevation data used for this contour were from September 5, 1990 for wells BH9-II, PL1, PL2 and PL3 and adjusted water levels from September 1986, September 1983 and October 1982 for the remaining wells. The historical water level data was adjusted to correspond as closely as possible with the September 1990 data by comparing the elevation data from BH9-II on the different monitoring dates.

Of note from the geologic cross section are: the apparent horizontal correlation of the upper silt unit / sand aquifer contact between wells BH9, PL1 and PL3; and, the large rise



LEGEND

- SCREENED INTERVAL
- INTERPRETED POTENTIOMETRIC SURFACE (from Figure 3 Potentiometric Surface Main Aquifer)
- INTERPRETED GEOLOGICAL CONTACT

FIGURE 3

CROSS SECTION A - A'
(South to North)

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E. PAUZE LANDFILL SITE

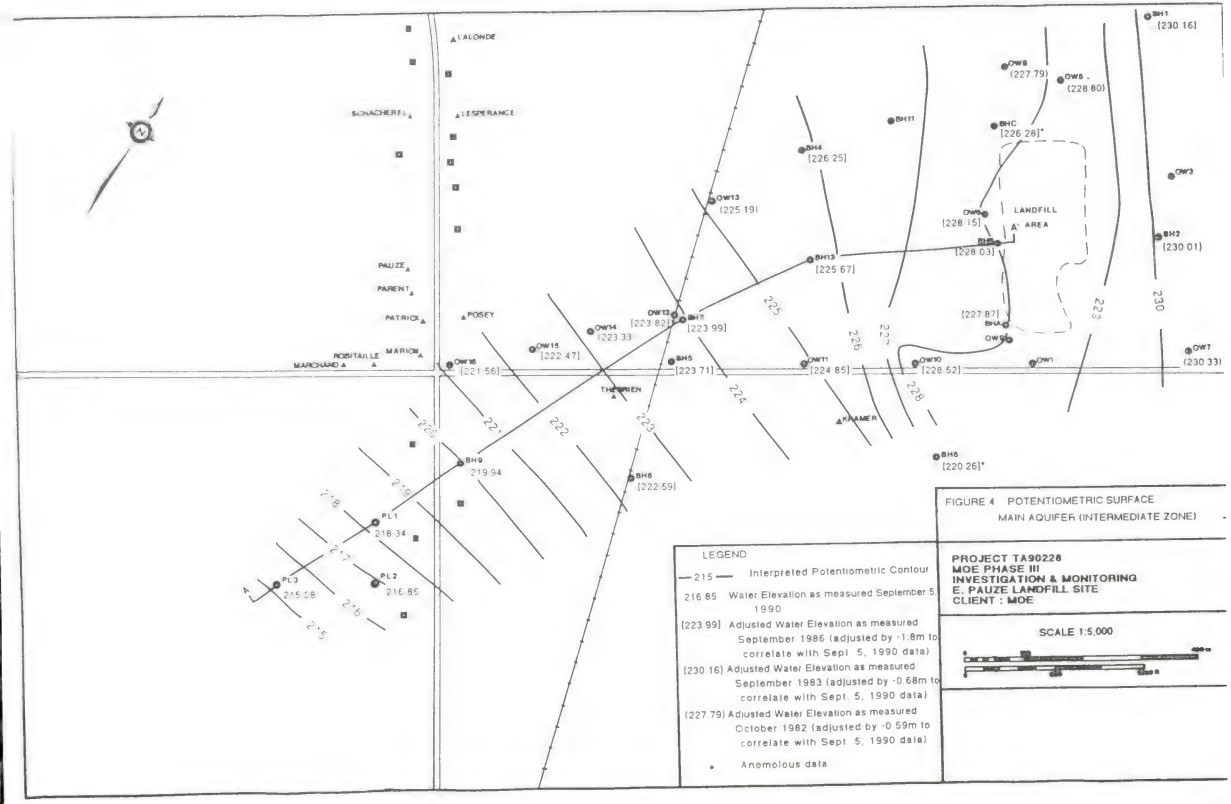

FIGURE 4 POTENTIOMETRIC SURFACE
MAIN AQUIFER (INTERMEDIATE ZONE)

LEGEND

— 215 — Interpreted Potentiometric Contour

216.85 Water Elevation as measured September 5, 1990

[223.99] Adjusted Water Elevation as measured September 1986 (adjusted by -1.8m to correlate with Sept. 5, 1990 data)

(230.16) Adjusted Water Elevation as measured September 1983 (adjusted by -0.68m to correlate with Sept. 5, 1990 data)

(227.79) Adjusted Water Elevation as measured October 1982 (adjusted by -0.59m to correlate with Sept. 5, 1990 data)

* Anomolous data

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E. PAUZE LANDFILL SITE
CLIENT : MOE

SCALE 1:5,000

0 200m 400m

(approximately 17 metres) in the elevation of the sand aquifer / silt till unit contact from BH9 to PL1. The elevation of the top of the till unit at the three locations drilled by Terraqua differed by only 1 to 2 metres.

The potentiometric surface contour illustrates the general groundwater flow path within the main aquifer. Of note from this contour are: the apparent increased gradient (slope) of the potentiometric surface in the present study area; and, the gradual change in flow direction from southwesterly between the Site and approximately 300 metres west of the Site to a southerly direction further downgradient from the Site. Close examination of Figure 4 shows the slight offset of the geologic–section line from the groundwater flow direction in the present study area. It appears from the flow pattern that, if wells OW12 and BH9 are along the axis of the landfill plume then, wells PL1 and PL3 are slightly west of the axis and well PL2 is slightly east of the axis.

The horizontal gradients in the area between well locations OW12 and BH9 and the area between well locations PL1 and PL3 are, respectively, 0.008 and 0.016 metres/metre. The increase in the gradient of the potentiometric surface may be a response to the apparent thinning of the aquifer between well BH9 and the present downgradient study area.

The three wells installed in the present study area do not provide any information on the vertical hydraulic gradients beneath the study area. However, water levels at the BH9 well nest were monitored during the present study and are summarized on Table 3. Comparison of the water elevations indicates a large upward gradient between wells BH9–I (deep) and BH9–II (intermediate) of approximately 0.1 metres/metre. As this gradient is much greater than the horizontal gradient across this area, it appears that groundwater flow within the deep zone of the aquifer at this location is predominantly upward. This is likely a result of the apparent rise in the lower silt till unit between locations BH9 and PL1. The relatively low permeability of the till would act to control deep aquifer flow and redirect it upward and then across the area to the south.

Hydraulic gradients upgradient from location BH9, as presented in the 1983 GLAL report, indicate generally lateral flow across the area. The change in vertical gradient observed at

BH9 provides additional confirmation of the lower till unit change in elevation.

4.4.1 Groundwater Flow Velocities

Groundwater flow velocities can be calculated using the following equation for average linear flow velocity:

$$V = ki/n$$ where:

k is the hydraulic conductivity [L/T]
i is the horizontal hydraulic gradient [L/L]
n is the porosity of the material [dimensionless]

Using the range of in-situ hydraulic conductivities calculated from the response tests, the horizontal gradient from the interpreted groundwater flow contour and assuming a typical aquifer porosity of 0.3, the average linear flow velocity within the main aquifer beneath the present study area is calculated as follows:

$$V = ki/n$$

$$= (1.0 \times 10^{-4} \text{ to } 1.2 \times 10^{-5} \text{ m/s}) (0.016 \text{ m/m}) / 0.3$$
$$= 5.3 \times 10^{-6} \text{ to } 6.4 \times 10^{-7} \text{ m/s}$$
$$= 20 \text{ to } 168 \text{ metres/year}$$

The above groundwater flow velocity range represents the range of flow velocities within the sand aquifer beneath the study area. The lower range velocities would correspond to the silty fine grained sand layers while the higher velocities would correspond to the coarser grained zones. Dissolved constituents in the groundwater would not be expected to travel any faster than the flow velocities in the coarser zones.

The 1983 GLAL study determined groundwater flow velocities upgradient of the present study area. A range of flow velocities between 40 and 117 metres/year was estimated using an estimated hydraulic conductivity range of 5.5×10^{-3} to 1.6×10^{-2} cm/s, a horizontal hydraulic gradient of 0.007 metres/metre and an assumed porosity of 0.3. The upper end of this range is somewhat less than the upper range estimated in the current study. This is due entirely to the increased hydraulic gradients beneath the present study area.

5.0 UPDATE ON GROUNDWATER QUALITY ASSESSMENT

5.1 GROUNDWATER SAMPLING AND ANALYSES RESULTS

Water samples were collected from PL1, PL2 and PL3 on August 15, 1990 and from BH9–II on September 5, 1990. The three samples from the recently installed wells were collected using the dedicated sampling equipment installed for well development. Samples were collected after ten well volumes of water had been removed. Well BH9–II was sampled using pre–rinsed new WaTerra tubing, with an attached foot valve and WaTerra Power Pump. Three well volumes were removed prior to sampling.

All samples were submitted to Enviroclean laboratory in London, Ontario for analysis of general indicator parameters and a VOC scan. Appendix I provides the laboratory report of results. The scan list included the MISA 16, 17 and 18 list compounds, all of the VOC routinely analysed by the MOE laboratory for this Site plus several additional VOC. All of the indicator parameters were analysed with the exception of COD.

The August/September 1990 results are discussed in the subsequent sections.

5.2 GENERAL CHEMISTRY RESULTS

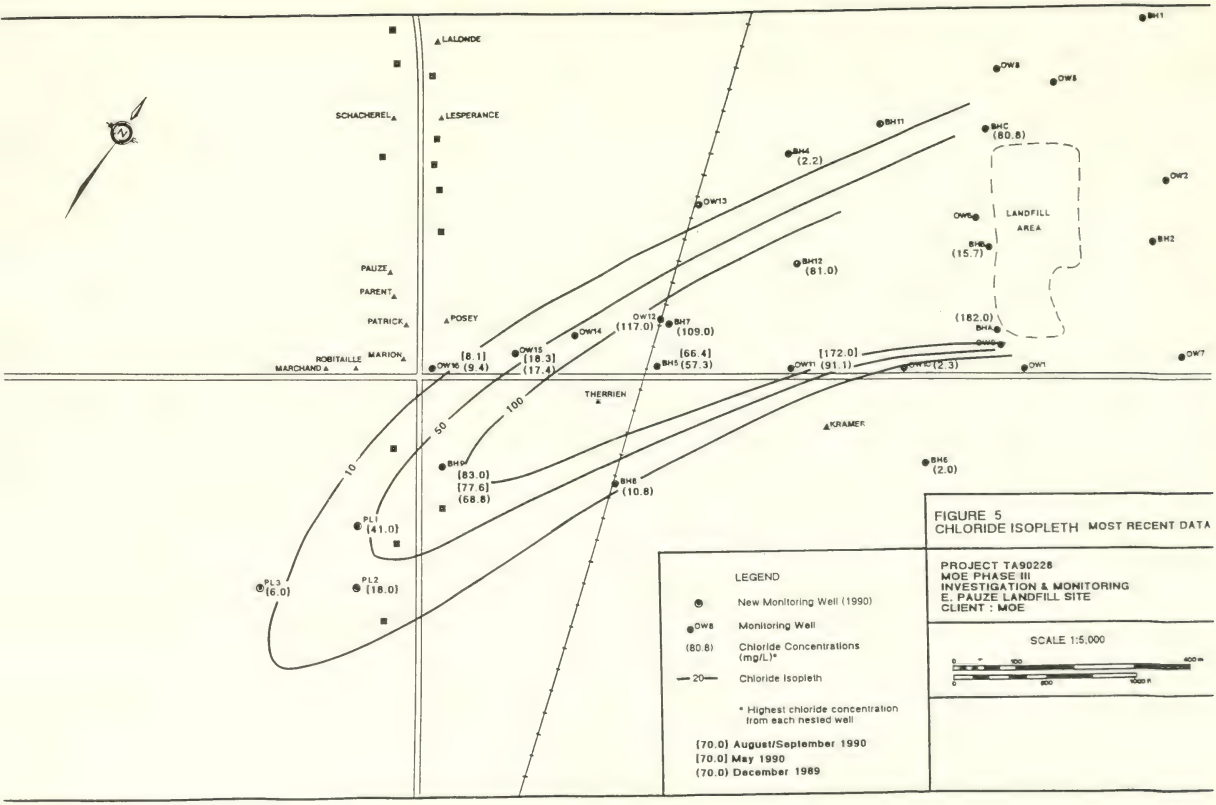
Examination of the results indicates elevated chloride ion, phenols and several other indicator parameters at some or all of the newly installed wells. As indicated in Section 3.0, chloride and phenols are good indicators of the extent of groundwater impact (both inorganic and organic) from the Site and therefore, have been selected for isopleth mapping. Mapping has been completed using the most recent data collected by MOE (December 1989 and May 1990) and the August/September 1990 data from the present study. Because the data are from different dates the isopleths may only be considered approximate. Isopleths have been prepared in both plan view (as in Section 3.0) and in section (along the approximate landfill plume axis). Chloride and phenols results are addressed under the subsequent headings.

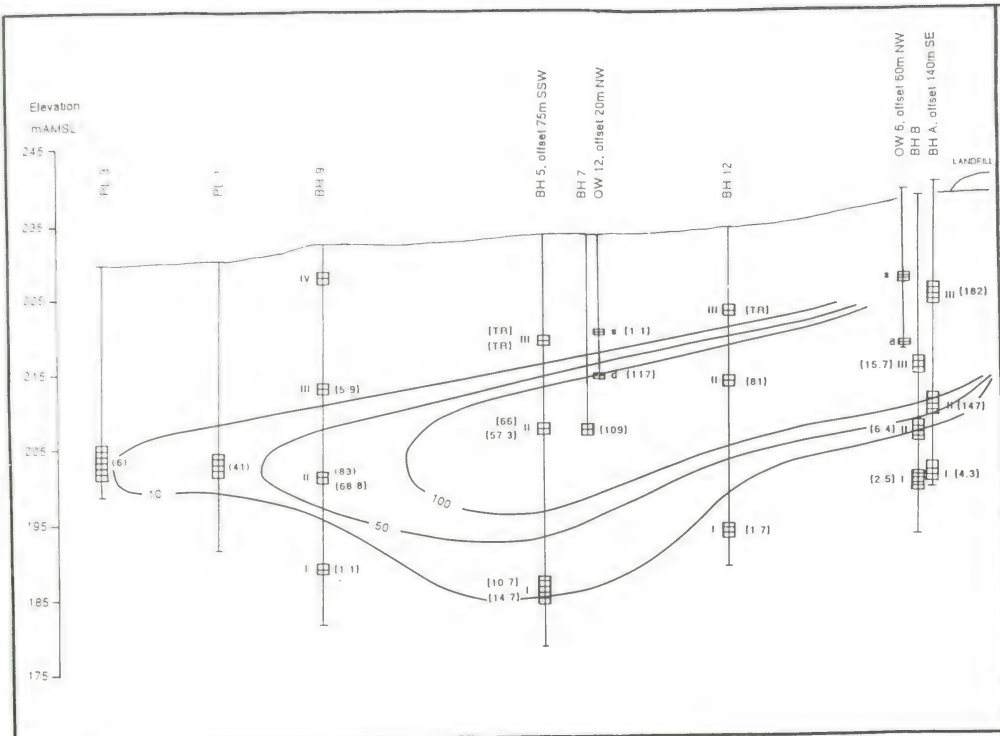
Chloride

Figures 5 and 6 present the plan and section view isopleths, respectively, for the most recent chloride data.

The plan view isopleth indicates a similar plume configuration as interpreted with the previous data sets. The addition of the PL1, PL2 and PL3 data provides definition at the leading edge of the plume. The extent of the chloride plume (as marked by the 10 mg/L contour) is shown to extend past well PL3. The configuration has been interpreted this way because of the groundwater flow pattern, which indicates the axis (centre line) of the plume appears to be between wells PL1 and PL2. This point is further addressed in Section 5.4 (Plume Migration Rates).

The section view isopleth presents data from several wells at or near the plume axis and from different depths within the aquifer. In general, the plume appears to be most concentrated in the shallow zone near the landfill and then slopes downward slightly into the intermediate zone of the aquifer further from the Site. The deep aquifer data from locations BH5 and BH9 illustrates the transition between where the plume advances to depth at BH5 to where the upward gradient in the deep zone (near BH9) forces the plume upward and between the upper silt and lower silt till units south of BH9. On this particular section the 10 mg/L contour does not appear to have reached PL3, although the 6 mg/L value is likely above background concentration.


LALONDE
SCHACHEREL
LESPERANCE
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3 (15.7)
BH4 (2.2)
BH5 (57.3)
BH6 (2.0)
BH7 (109.0)
BH8 (10.8)
BH9 [83.0] [77.6] (68.8)
BH10 (182.0)
BH11
BH12 (81.0)
BHC (80.8)
OW1
OW2
OW3
OW4
OW5
OW6
OW7
OW8
OW9 [66.4]
OW10 (9.4)
OW11 [172.0] (91.1)
OW12 (2.3)
OW13
OW14
OW15 [8.1] [16.3] (17.4)
OW16 (117.0)
PL1 [41.0]
PL2 [18.0]
PL3 (6.0)
10
50
100
LEGEND
New Monitoring Well (1990)
OW8 Monitoring Well
(80.8) Chloride Concentrations (mg/L)*
20 Chloride Isopleth
* Highest chloride concentration from each nested well
[70.0] August/September 1990
[70.0] May 1990
(70.0) December 1989
FIGURE 5
CHLORIDE ISOPLETH MOST RECENT DATA
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 800 1600 ft



LEGEND

CHLORIDE CONCENTRATIONS (mg/L)

(6) AUG/SEPT 1990 (Terraqua)

{5.9} DEC 1989 (MOE)

[66] MAY 1990 (MOE)

— CHLORIDE ISOPLETH (mg/L)

FIGURE 6
CHLORIDE
(MOST RECENT DATA)

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E. PAUZE LANDFILL SITE

Phenols

Figures 7 and 8 present the plan and section view isopleths, respectively, for the most recent phenols data.

The updated plan view isopleth, using the phenols data from the new wells, completes the configuration of the phenols plume at the leading edge. Neither the sample from well PL2 or PL3 had phenols reported above detection limits. The phenols plume appears to lag slightly behind the chloride plume advancement (up to about 1,250 metres from the site) with a slightly narrower plume width.

The section view isopleth indicates a similar plume configuration as presented with chloride. Plume definition is unknown closer to the landfill do to the lack of recent data for OW6s.

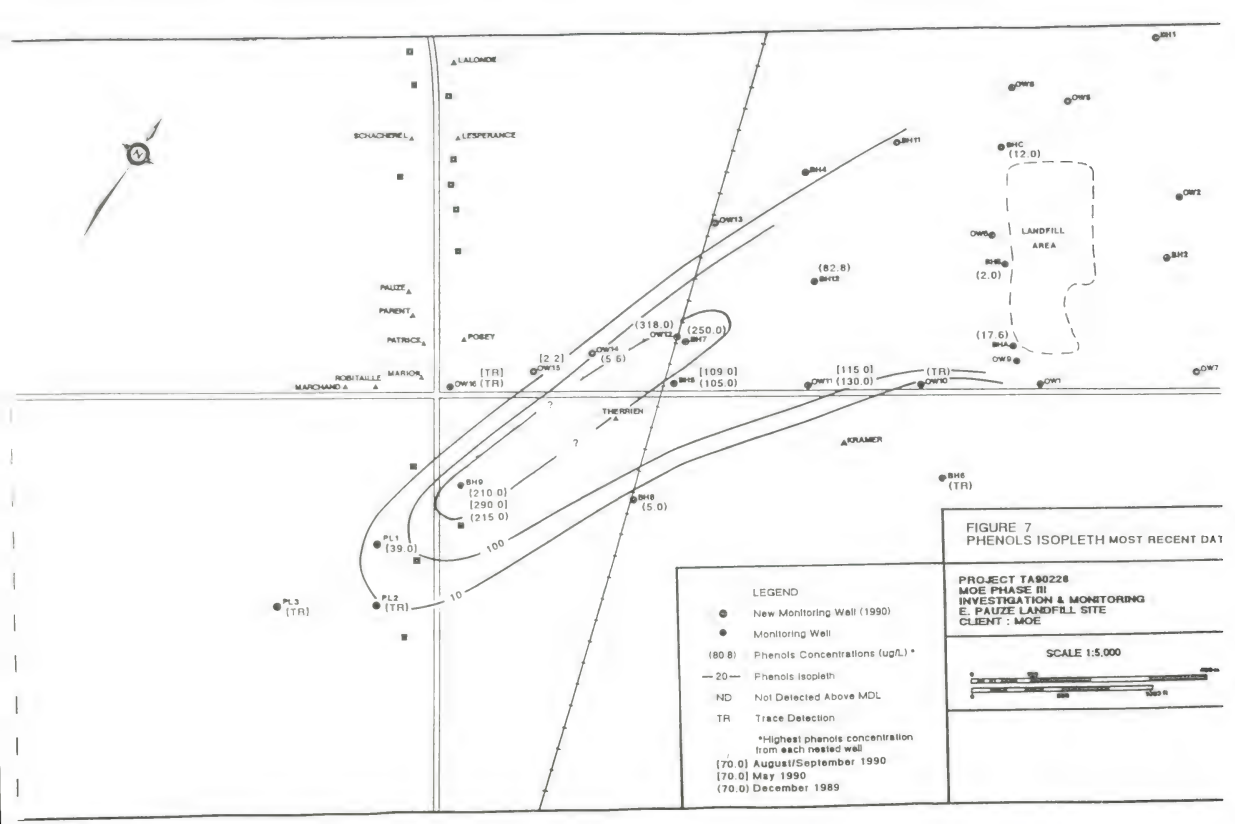
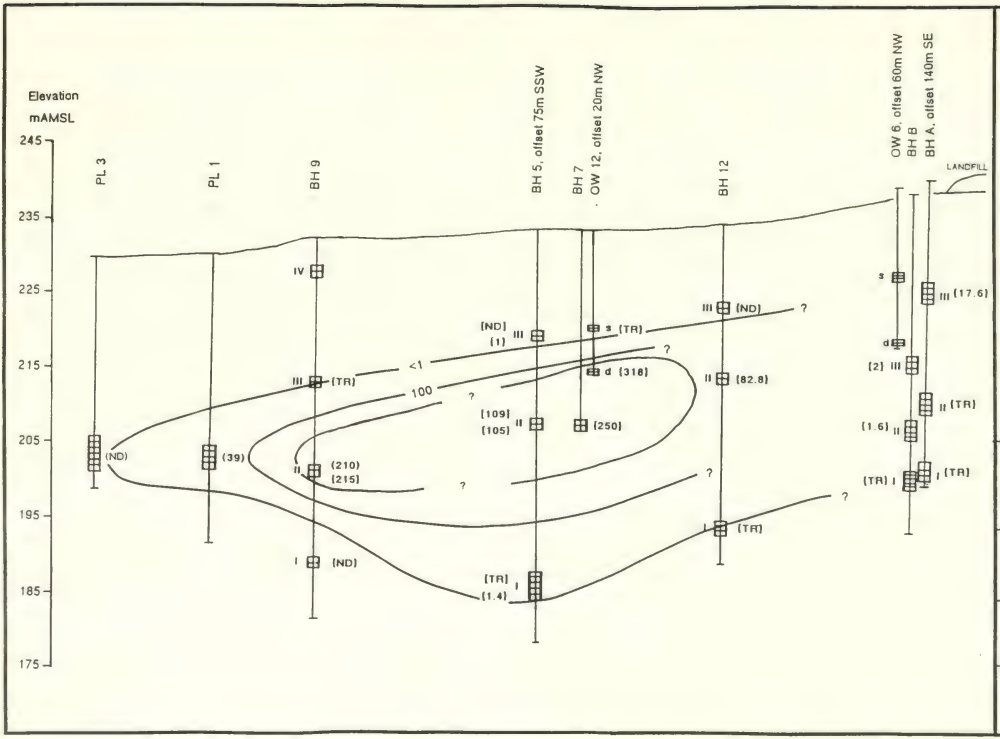


FIGURE 7
PHENOLS ISOPLETH MOST RECENT DAT



LEGEND

PHENOLS CONCENTRATIONS (ug/L)

(39) AUG/SEPT 1990 (Terraqua)

[109] MAY 1990 (MOE)

(210) DEC 1990 (MOE)

← PHENOLS ISOPLETH (ug/L)

FIGURE 8

PHENOLS (MOST RECENT DATA)

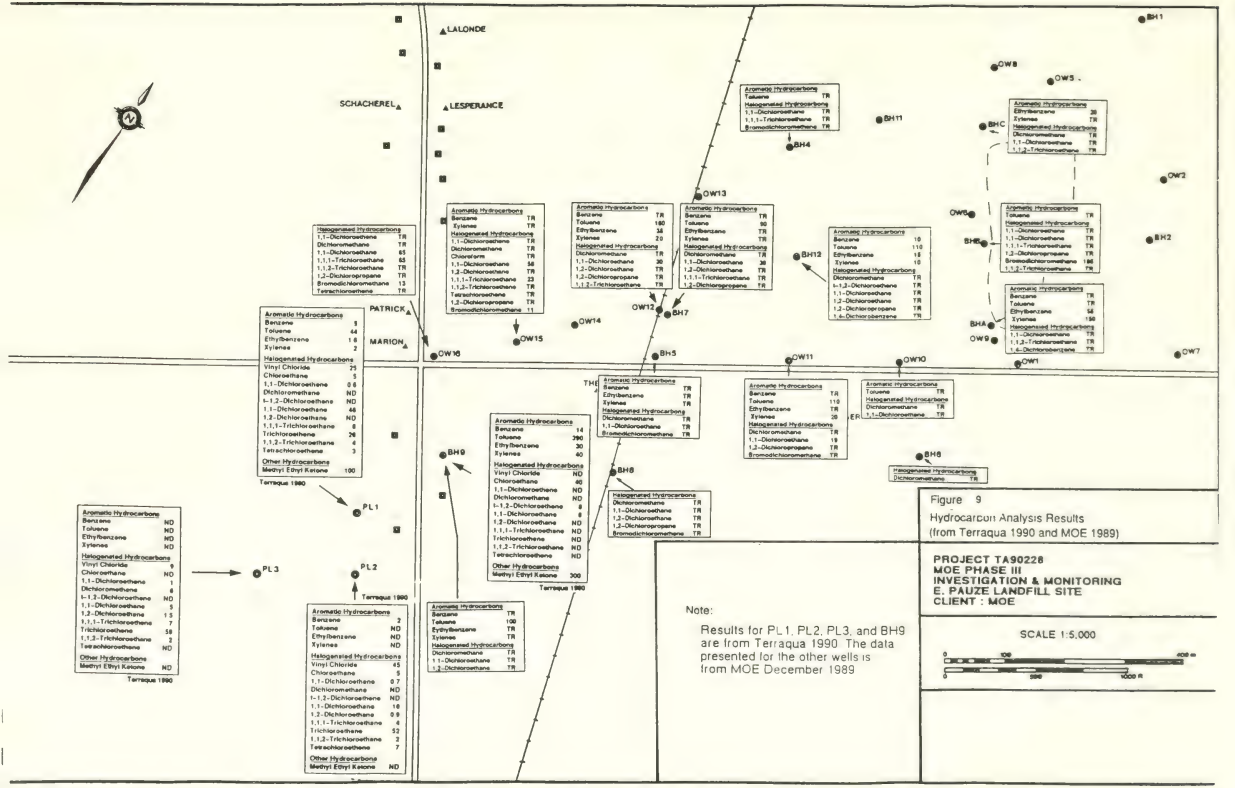
PROJECT TA 90228
E. PAUZE LANDFILL SITE

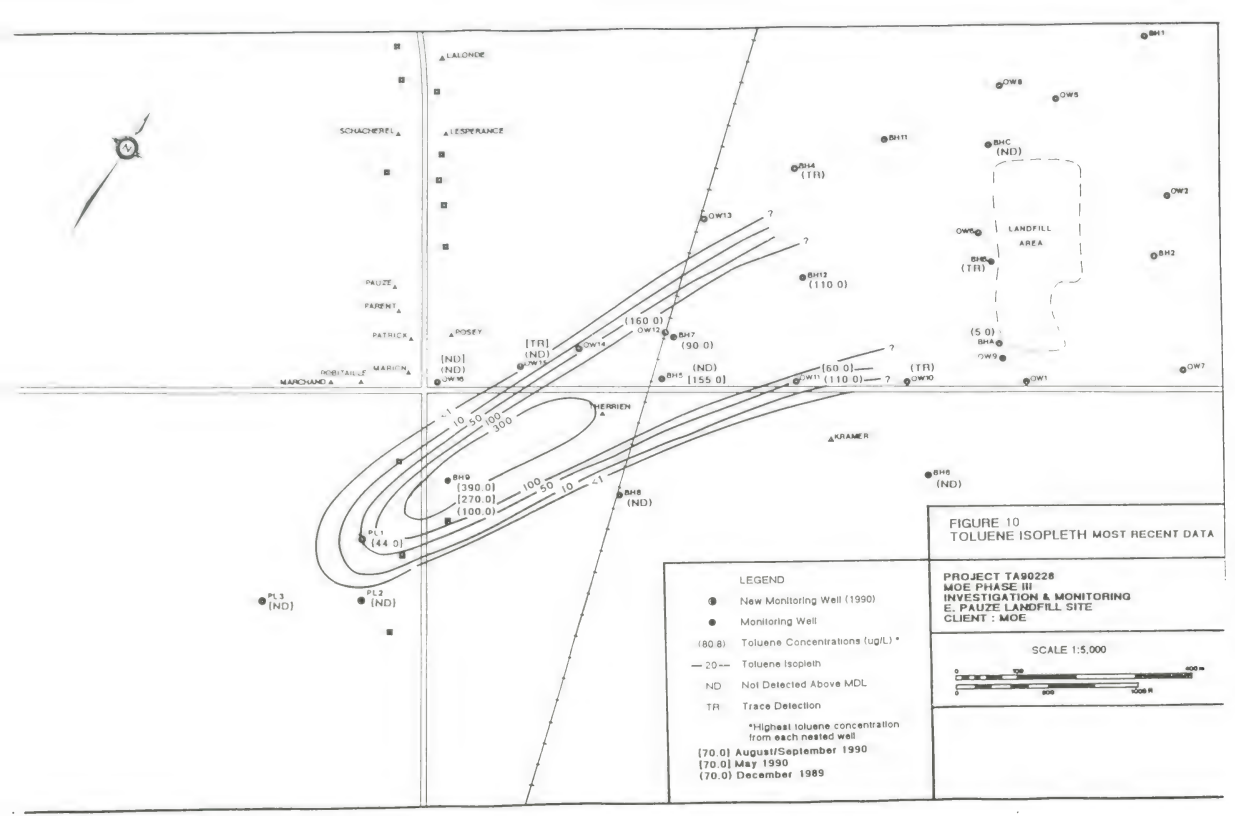
5.3 VOLATILE ORGANIC COMPOUND (VOC) RESULTS

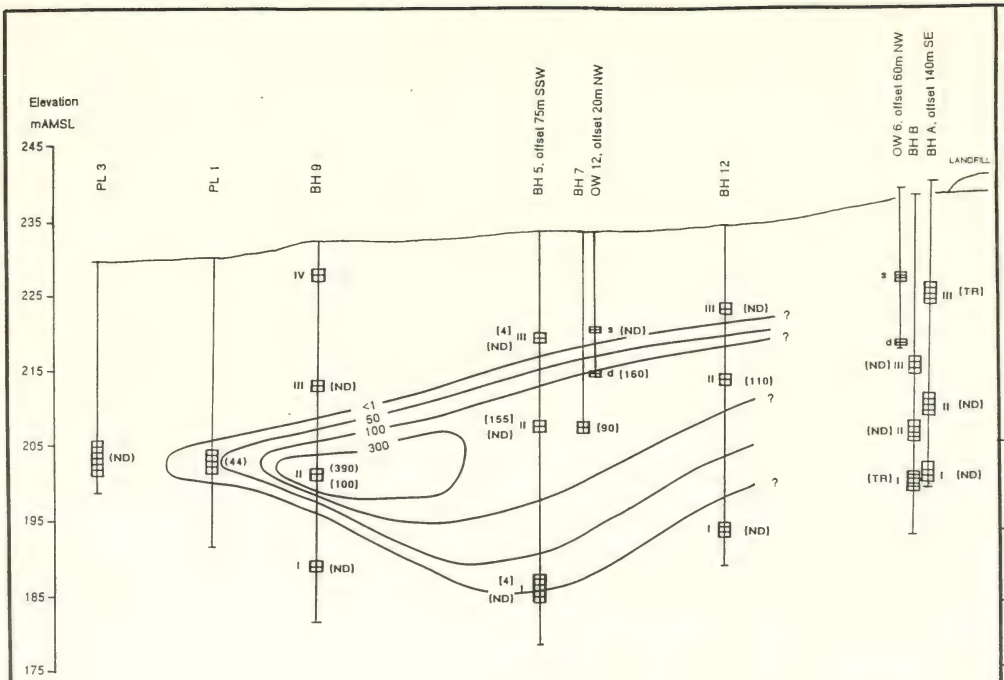
Sixteen (16) VOC were detected in the samples collected from the four wells. Figure 9 presents a list of these compound results (labelled Terraqua 1990) as well as the December 1989 VOC results from MOE for other downgradient wells and BH9. Several of the VOC including the BTEX aromatic group, TCE, chloroethane, vinyl chloride, 1,1-dichloroethane and methyl ethyl ketone (MEK), were reported in elevated concentrations and warrant further discussion.

The BTEX group have previously been identified to have emanated from the site. Benzene, while present in only trace amounts or slightly above detection limits, appears to have migrated the furthest from the site, with a 2 ug/L concentration reported for the sample from PL2. The presence of ethylbenzene and xylenes are somewhat erratic throughout the core of the downgradient landfill plume, with the furthest downgradient detections in the sample collected from location PL1. Of the BTEX group, toluene, is present in the expected locations and highest concentrations in the downgradient groundwater. For this reason, it has been selected for updated isopleth mapping (Figures 10 and 11). The results from the three newly installed wells complete the configuration of the toluene plume at the plume's leading edge, as presented on Figure 10. This plume appears to have migrated up to about 1,250 metres from the Site, a similar distance as the phenols plume. The plume width is much narrower than the chloride plume, likely a result of toluene's biodegradation outside the anaerobic core of the landfill plume as described in Section 3.0. Definition of the plume configuration immediately downgradient of the Site is poor due to the unknown concentrations emanating from the area near location OW6. The section view isopleth indicates a similar configuration as chloride and phenols.

Of the individual chlorinated compounds with notable results from the 1990 analyses, both vinyl chloride (chloroethene) and chloroethane have not been historically analysed. Both compounds are single chlorine halocarbons, known to be biodegradation products of other halocarbons with 3 or 4 chlorines. For instance, vinyl chloride is known to be a biodegradation product of TCE. In a methanogenic environment, as in the anaerobic landfill plume emanating from the Site, such biotransformations will occur. Chloroethane was detected at 40 ug/L for


LALONDE
LESPERANCE
SCHACHEREL
PATRICK
MARION
THE
ER
BH1
BH2
BH3
BH4
BH5
BH6
BH7
BH8
BH9
BH10
BH11
BH12
BHC
OW1
OW2
OW5
OW6
OW7
OW8
OW9
OW10
OW11
OW12
OW13
OW14
OW15
OW16
PL1
PL2
PL3
Halogenated Hydrocarbons
1,1-Dichloroethene TR
Dichloromethane TR
1,1-Dichloroethane 65
1,1,1-Trichloroethane 65
1,1,2-Trichloroethane TR
1,2-Dichloropropane TR
Bromodichloromethane 13
Tetrachloroethene TR
Aromatic Hydrocarbons
Benzene 5
Toluene 44
Ethylbenzene 18
Xylenes 2
Halogenated Hydrocarbons
Vinyl Chloride 75
Chloroethane 5
1,1-Dichloroethene 0.6
Dichloromethane ND
t-1,2-Dichloroethene ND
1,1-Dichloroethane 46
1,2-Dichloroethane ND
1,1,1-Trichloroethane 8
Trichloroethene 26
1,1,2-Trichloroethene 4
Tetrachloroethene 3
Other Hydrocarbons
Methyl Ethyl Ketone 100
Terraqua 1990
Aromatic Hydrocarbons
Benzene ND
Toluene ND
Ethylbenzene ND
Xylenes ND
Halogenated Hydrocarbons
Vinyl Chloride 9
Chloroethane ND
1,1-Dichloroethene 1
Dichloromethane 6
t-1,2-Dichloroethene ND
1,1-Dichloroethane 5
1,2-Dichloroethane 1.5
1,1,1-Trichloroethane 7
Trichloroethene 58
1,1,2-Trichloroethene 2
Tetrachloroethene ND
Other Hydrocarbons
Methyl Ethyl Ketone ND
Terraqua 1990
Aromatic Hydrocarbons
Benzene 2
Toluene ND
Ethylbenzene ND
Xylenes ND
Halogenated Hydrocarbons
Vinyl Chloride 45
Chloroethane 5
1,1-Dichloroethene 0.7
Dichloromethane ND
t-1,2-Dichloroethene ND
1,1-Dichloroethene 10
1,2-Dichloroethene 0.9
1,1,1-Trichloroethane 4
Trichloroethene 52
1,1,2-Trichloroethene 2
Tetrachloroethene 7
Other Hydrocarbons
Methyl Ethyl Ketone ND
Aromatic Hydrocarbons
Benzene TR
Xylenes TR
Halogenated Hydrocarbons
1,1-Dichloroethene TR
Dichloromethane TR
Chloroform TR
1,1-Dichloroethane 54
1,2-Dichloroethane TR
1,1,1-Trichloroethane 23
1,1,2-Trichloroethane TR
Tetrachloroethene TR
1,2-Dichloropropane TR
Bromodichloromethane 11
Aromatic Hydrocarbons
Benzene TR
Toluene 180
Ethylbenzene 34
Xylenes 20
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethane 30
1,2-Dichloroethane TR
1,2-Dichloropropane TR
1,1,2-Trichloroethane TR
Aromatic Hydrocarbons
Benzene TR
Toluene 160
Ethylbenzene TR
Xylenes TR
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethane 38
1,2-Dichloroethane TR
1,1,1-Trichloroethane TR
1,2-Dichloropropane TR
Aromatic Hydrocarbons
Benzene 14
Toluene 390
Ethylbenzene 30
Xylenes 40
Halogenated Hydrocarbons
Vinyl Chloride ND
Chloroethane 46
1,1-Dichloroethene ND
Dichloromethane ND
t-1,2-Dichloroethene 8
1,1-Dichloroethane 6
1,2-Dichloroethane ND
1,1,1-Trichloroethane ND
Trichloroethene ND
1,1,2-Trichloroethene ND
Tetrachloroethene ND
Other Hydrocarbons
Methyl Ethyl Ketone 300
Terraqua 1990
Aromatic Hydrocarbons
Benzene TR
Toluene 100
Ethylbenzene TR
Xylenes TR
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethene TR
1,2-Dichloroethene TR
Aromatic Hydrocarbons
Benzene TR
Toluene 180
Ethylbenzene 34
Xylenes 20
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethane 30
1,2-Dichloroethane TR
1,2-Dichloropropane TR
1,1,2-Trichloroethane TR
Aromatic Hydrocarbons
Benzene TR
Toluene 110
Ethylbenzene 18
Xylenes 10
Halogenated Hydrocarbons
Dichloromethane TR
t-1,2-Dichloroethene TR
1,1-Dichloroethane TR
1,2-Dichloroethane TR
1,2-Dichloropropane TR
1,4-Dichlorobenzene TR
Aromatic Hydrocarbons
Benzene TR
Toluene TR
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethane TR
1,2-Dichloroethane TR
1,2-Dichloropropane TR
Bromodichloromethane TR
Aromatic Hydrocarbons
Benzene TR
Toluene 110
Ethylbenzene TR
Xylenes 20
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethane 19
1,2-Dichloropropane TR
Bromodichloromethane TR
Aromatic Hydrocarbons
Toluene TR
Halogenated Hydrocarbons
Dichloromethane TR
Halogenated Hydrocarbons
Dichloromethane TR
Aromatic Hydrocarbons
Ethylbenzene 38
Xylenes TR
Halogenated Hydrocarbons
Dichloromethane TR
1,1-Dichloroethane TR
1,1,2-Trichloroethane TR
Aromatic Hydrocarbons
Toluene TR
Halogenated Hydrocarbons
1,1-Dichloroethene TR
1,1-Dichloroethane TR
1,1,1-Trichloroethane TR
1,2-Dichloropropane TR
Bromodichloromethane 180
1,1,2-Trichloroethane TR
Aromatic Hydrocarbons
Benzene TR
Toluene TR
Ethylbenzene 58
Xylenes 190
Halogenated Hydrocarbons
1,1-Dichloroethene TR
1,1-Dichloroethane TR
1,1,2-Trichloroethane TR
1,4-Dichlorobenzene TR
Note:
Results for PL1, PL2, PL3, and BH9 are from Terraqua 1990. The data presented for the other wells is from MOE December 1989
Figure 9
Hydrocarbon Analysis Results
(from Terraqua 1990 and MOE 1989)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 500 1000 ft


LALONDE
L'ESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
MARION
POIRIER
MARCHAND
LANDFILL AREA
BH1
OW8
OW5
BH11
BHC (ND)
BH4 (TR)
OW2
OW13
OW5
BH2
BH5 (TR)
BH12 (110.0)
(160.0)
OW12
BH7 (90.0)
OW14
[TR] (ND)
OW17
[ND] (ND)
OW15
BH5 (ND) [155.0]
(5.0)
BHA
OW9
OW7
OW11 (110.0)
[60.0]
(TR)
OW10
OW1
<1
10
50
100
300
HERRIEN
KRAMER
BH9 [390.0] [270.0] (100.0)
BH8 (ND)
BH6 (ND)
PL1 (44.0)
PL3 (ND)
PL2 (ND)
FIGURE 10
TOLUENE ISOPLETH MOST RECENT DATA
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) Toluene Concentrations (ug/L) *
—20— Toluene Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest toluene concentration from each nested well
[70.0] August/September 1990
[70.0] May 1990
(70.0) December 1989
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 120 400 m
0 600 1000 ft



LEGEND

TOLUENE CONCENTRATIONS (ug/L)

(44) AUG/SEPT 1990 (Terraqua)

[155] MAY 1990 (MOE)

[100] DEC 1989 (MOE)

— TOLUENE ISOPLETH (ug/L)

FIGURE 11
TOLUENE
(MOST RECENT DATA)

PROJECT TA 90228
E. PAUZE LANDFILL SITE

the BH9-II sample and at 5 ug/L for both the PL1 and PL2 samples. This appears to indicate that chloroethane may be present further upgradient within the landfill plume, but has not migrated further than about 1,250 metres from the Site. Vinyl chloride, was not reported to be present at BH9-II but was present at the three newly installed wells (up to 45 ug/L at PL2). It appears then, that it may not be present further upgradient within the anaerobic core of the plume. This may be a result of further biodegradation within the plume core where vinyl chloride itself is broken down. If this were the case, the vinyl chloride present in front of the main landfill plume, would likely be the result of TCE degradation in previous years.

1,1-Dichloroethane, analysed historically, is present both immediately downgradient of the landfill in trace concentrations and further downgradient at the newly installed wells. The highest reported concentrations are for those locations outside the core of the landfill plume (such as at OW16d, OW15d and the three newly installed wells). This compound will also biodegrade, however, not as readily as other halocarbons such as TCE. This may explain it's apparent persistence. It's presence on the northwestern edge of the landfill plume may be a result of other possible source areas as previously indicated in Section 2.0.

The other halocarbon of note is TCE. It was reported to be present only in the newly installed wells with the highest concentration found at the furthest downgradient location, PL3 (59 ug/L). As described in Section 3.0, TCE was not detected in 1989 in the groundwater upgradient of the new wells. It was stated that this was likely the result of it being anaerobically biodegraded. It was also indicated that TCE was present, historically, in advance of the anaerobic core of the landfill plume and under such aerobic conditions would likely migrate and persist. The recent results appear to confirm this interpretation. Figures 12 and 13 have been prepared to illustrate the most recent TCE distribution. The isopleth contours have been indented on the upgradient end of the plume to illustrate the likely pattern for the core of the landfill plume biodegrading the centre of the TCE plume. The downgradient extent of the TCE plume is unknown, as presented on the isopleth maps.

One additional VOC compound, methyl ethyl ketone (MEK), was reported for the samples from BH9-II and PL1 (300 and 100 ug/L, respectively). MEK is a solvent used predominantly in the surface coating industry. It is not known for certain whether MEK was disposed in bulk

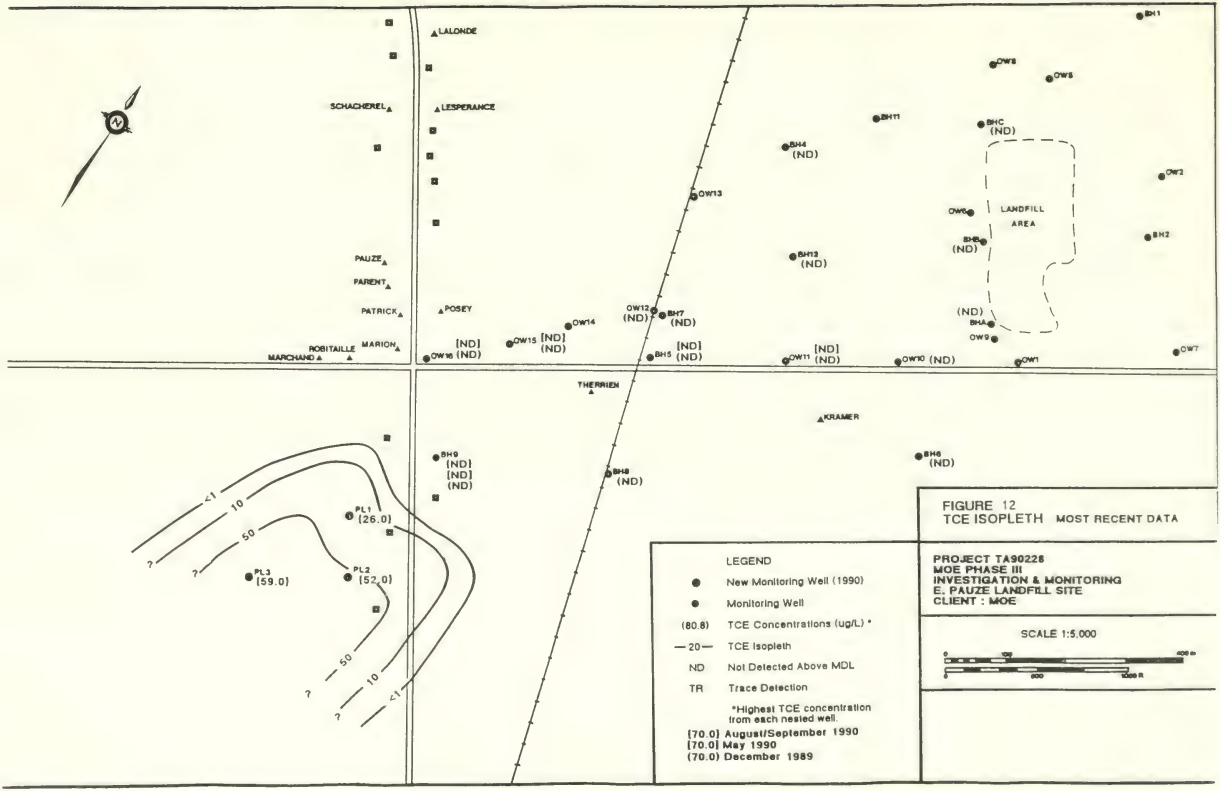
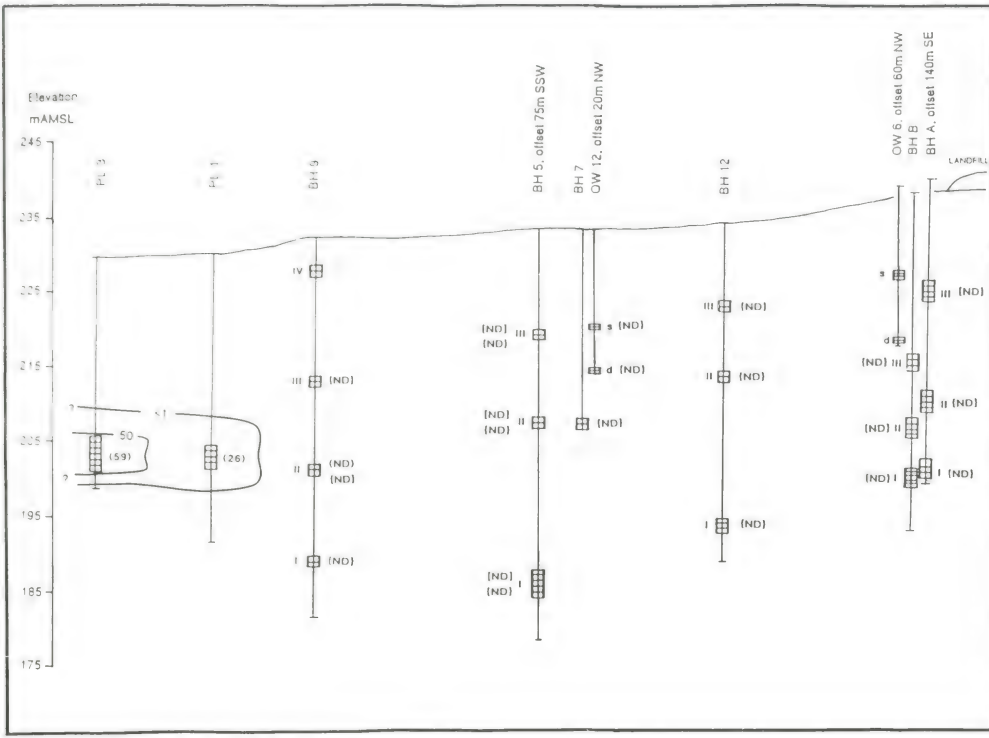


FIGURE 12
TCE ISOPLETH MOST RECENT DATA

PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE



LEGEND

TCE CONCENTRATIONS (ug/L)

(59) AUG/SEPT 1990 (Terraqua)

[ND] MAY 1990 (MOE)

(ND) DEC 1990 (MOE)

— TCE ISOPLETH (ug/L)

FIGURE 13
TCE
(MOST RECENT DATA)

PROJECT TA 90228
E. PAUZE LANDFILL SITE

at the Site, however, it's presence in the downgradient intermediate zone of the aquifer indicates it may have been. It may also have been a result of a different and unknown source. Analyses of samples collected near the landfill may aid in determining this. The concentrations in which it is found (up to 300 ug/L) indicates that MEK may rank as high as toluene and TCE as the organic parameters of primary concern in the main aquifer.

It should be noted when considering the above discussion of results, that only one round of data has been collected from the new wells. This represents only a 'snapshot' of groundwater conditions and additional data collection would be appropriate to affirm the interpretations.

5.4 PLUME MIGRATION RATES

Projecting plume migration rates is not an easy task. Many physical and chemical processes are occurring within an aquifer system such as: advection (flow velocity effects), dilution, sorption and biodegradation. Each chemical parameter, both inorganic and organic, behaves differently in a groundwater system and as emphasized in this report, many parameters behave differently in the presence of others (ie. TCE with a high COD).

Chloride ion is generally considered the most reliable chemical parameter used in projecting landfill migration rates, because of its nature. This was discussed in some detail in Section 3.0. As a result, it has been selected to estimate migration rates.

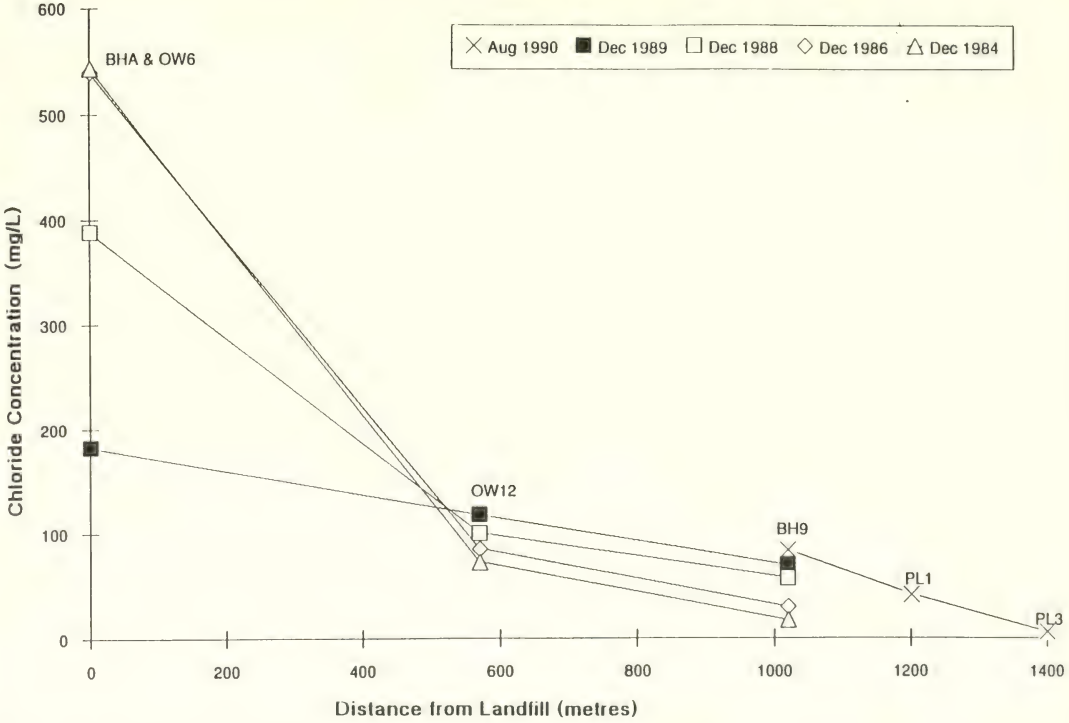
Estimating the "leading edge" migration rate can be performed by comparison of the isopleth maps from different years. However, the 1981 and 1983 data sets either did not include location BH9-II or had an anomalous chloride result. By 1984, the chloride plume had already migrated past BH9-II making definition of the leading edge in subsequent years difficult. Nevertheless, isopleth mapping between December 1984 and August/September 1990 (an approximate 5 year, 8 month period) indicates a leading edge movement of approximately 340 metres. This indicates an average migration rate of 60 metres/year, a value slightly less than that estimated by GLAL in 1984 (70 metres/year). Assuming plume definition near the leading edge (identified as 10 mg/L) is correct in August 1990, the chloride

plume has migrated approximately 1,375 metres southwest from the landfill Site along a flow path approximately 1,500 metres long.

Another method of estimating the chloride plume migration rate is by examining the chloride concentration trends at various downgradient locations. Figure 14 presents the chloride concentrations versus distance from Site for selected wells along or near the plume axis. Locations PL1 and PL3, although apparently slightly off the axis, have been included for comparison purposes. Data is presented for various times in the 1984 to 1990 periods. Notable from this graph are the fluctuating concentrations near the landfill, although this is likely the result of ceased monitoring at well OW6s in 1987. Results from locations OW12d and BH9-II (located approximately 570 and 1,020 metres from the Site along the plume axis) indicate generally similar increasing concentration rates. Results for these two wells have been "blown-up" and presented on Figure 15. The graph scale has enabled presentation of data for every year from 1984 to 1990. Most notable from this graph is the large increases in chloride concentration at both locations since December 1987 (up to 37 mg/L per year at BH9-II).

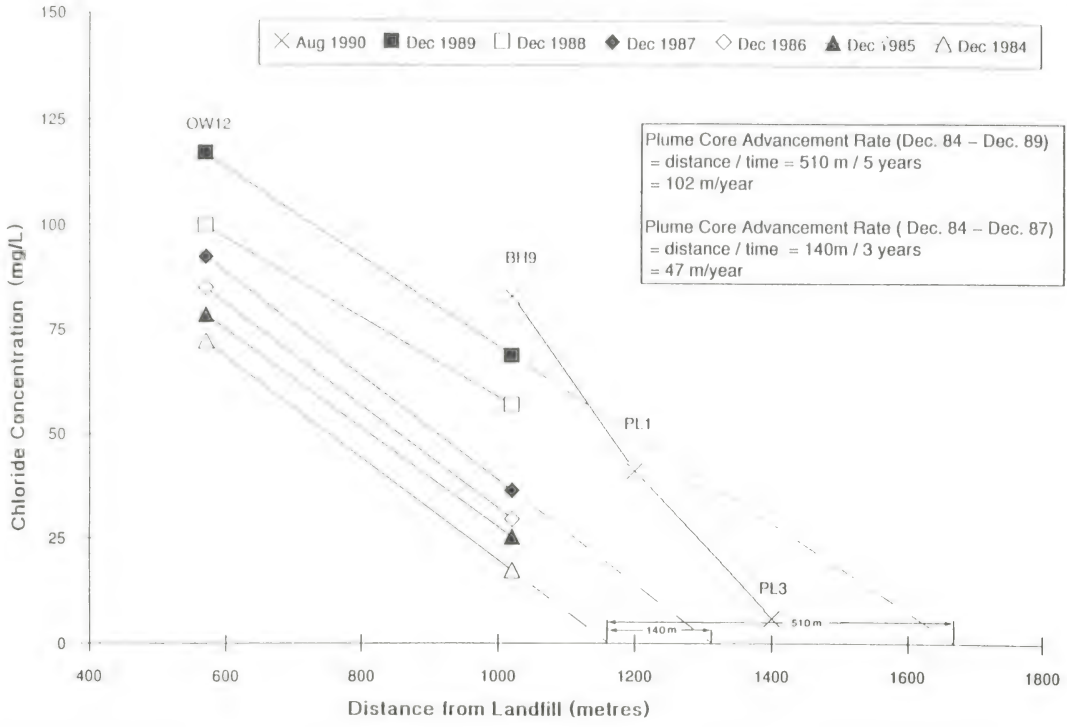
By extrapolating the trend in concentration between the two wells towards the 0 mg/L chloride axis, an estimation of the location of the plume's leading edge can be made. Inherent in this method is the assumption that the leading edge of the plume travels at the same rate as the core of the plume. Calculations of the advancement rate over the December 1984 to December 1987 and the December 1984 to December 1989 periods are presented on Figure 15. The 1984 to 1987 rate indicates advancement of 47 metres/year, a value slightly lower than the 60 metres/year estimated using the interpreted isopleths. The large chloride increases observed since December 1987 indicate a much larger average advancement rate over the 1984 to 1989 period of 102 metres/year. Again, it is emphasized that this is the advancement rate within the core of the plume. The leading edge of the plume may not show the effects of the increases at the core until several years later.

The projected 10 mg/L concentration using the December 1989 data would be located approximately 1,580 metres along the axis of the plume (1,450 metres from site). This is slightly further than the distance interpreted on the August 1990 isopleth (10 mg/L at about



PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

FIGURE 14
Chloride Concentrations Along Plume Axis
(1984 Through 1990)



	PROJECT TA90228 MOE Phase III Investigation and Monitoring E. Pauze Landfill Site Client : MOE	FIGURE 15 Chloride Plume Advancement Rate Projection

1,500 metres along plume axis or 1,375 metres from the landfill).

Also presented on Figure 15 are the recent chloride concentrations for wells PL1 and PL3. Results indicate the plume reaches these locations at a slower rate. This appears to be the case because these wells are located slightly off the plume axis. The plume's longitudinal advancement rate away from the axis would be expected to be less.

In summary, it appears that the leading edge of the plume has advanced at an average rate in the range of 45 to 60 metres/year. Recent trends within the core of the plume appear to indicate that the leading edge of the plume may accelerate in the very near future. Significant attenuation of the chloride plume does not appear to have occurred.

6.0 CONCLUSIONS

Based on the results of the assessment undertaken, the following conclusions are made:

1. Subsurface investigation in the area between 1,150 and 1,350 metres southwest of the Pauze Landfill Site indicates the silt till unit underlying the main aquifer rises in elevation by approximately 17 metres between the previously studied area and the present area. The lower zone of the main aquifer flow regime appears to be controlled by this lower till, whereby the aquifer flow is directed between the lower silt till unit and an upper silty unit. The horizontal hydraulic gradient, within this part of the aquifer, is greater than in the upgradient portion of the aquifer, resulting in increased groundwater flow velocities (ranging from 21 to 168 metres/year).

2. Downhole geophysical logging methods were employed at two of the three drilling locations. These methods proved to be a good tool for locating the vertical core of the landfill plume and verifying geostratigraphy.

3. An elongated, narrow chemical plume characterized by elevated inorganic solutes (ie. chlorides) and organic compounds (particularly phenols and toluene) is migrating from the Pauze Landfill Site within the main aquifer. Toluene and phenols appear to be confined to the anaerobic core of the landfill plume, which is characterized by elevated chemical oxygen demand (COD).

4. Other volatile organic compounds were identified in the downgradient groundwaters. A trichloroethene plume is present in advance of the chloride plume and appears to be biodegraded by the advancing anaerobic core of the landfill plume. Several organics resulting from the progressive biodegradation processes (ie. vinyl chloride, chloroethane) are also present. Methyl Ethyl Ketone, not analysed historically, was identified in relatively elevated concentrations within the furthest downgradient part of the landfill plume.

5. The plume of chloride ion appears to have migrated approximately 1,375 metres

southwest of the landfill site along a flow path approximately 1,500 metres long. This exceeds the 1300 metre distance, at which the plume was predicted to become indistinguishable from background groundwater quality (GLAL, 1984). The plume does not appear to have undergone significant retardation within the aquifer.

6. Assessment of the most conservative indicator of the landfill plume, chloride ion, indicates historical plume migration in the range of 45 to 60 metres/year.

7. Recent increases in chloride ion, phenols and toluene concentrations in the downgradient core of the landfill plume (i.e. near BH9-II) indicate plume strength in the area monitored by the newly installed wells will likely increase in the next few years. Increasing plume strength and increased flow velocities in the area recently studied indicate plume advancement will continue. This assumes that the downgradient aquifer provides a similar and minimal retardation capability as in upgradient areas.

8. The existing network of monitoring wells provide a reasonable definition of the landfill plume configuration, with wells located along the edge of the plume (OW10, BH4, OW15, OW16 and BH8), in the core of the plume (OW12, BH7, BH12, BH5, BH9 and PL1), at the leading edge of the plume (PL2 and PL3). The monitoring well network would be more complete with obtainable water quality data from OW6s and additional monitoring capabilities at the leading edge of the plume. Obtaining data from OW6s, if possible, would provide confirmation of expected reductions in organic compounds emanating from the north-central part of the landfill site. Additional capabilities at and beyond the leading edge of the chloride plume would enable determination of the configuration of the apparent TCE plume and allow for tracking of future chloride plume advancement.

9. The frequency of data collection from 1984 to 1990 (monthly in some cases) and the number of locations appears to be excessive. Concentration trends and existing definition of the various plumes present indicate reduced monitoring frequencies and less locations are appropriate.

10. It is expected that with continued plume migration, aromatic hydrocarbons such as toluene will migrate and persist as long as the landfill plume remains anaerobic. In time, the gradual decrease in the organic strength of the leachate from the site will allow for reversion to aerobic groundwater conditions and eventually lead to the degradation of toluene. The TCE plume, on the other hand, appears to be undergoing gradual biodegradation by the landfill plume. In front of the landfill plume, TCE would be expected to migrate and persist but also undergo dilution to lower concentrations. These processes in effect are a form of passive remediation, whereby the aquifer itself provides the ability to assimilate the effects of the landfill. It is expected however, that this will be a very slow process

11. Continued monitoring and additional well installation is appropriate to address plume migration. This will enable determination of whether downgradient aquifer materials are capable of assimilating the landfill plume.

7.0 RECOMMENDATIONS

The subsequent recommendations are made for future monitoring and investigation at the Pauze Landfill Site.

Upgrading Monitoring Network

Additional well installation is recommended if the chloride plume is to be tracked, past the present leading edge. Installation of two to three wells would likely be required to accomplish this.

The apparent lack of data in the north–central part of the landfill, should be addressed by continued attempts to obtain samples from well OW6s. This will enable verification that organic leachate strength is lessening.

With respect to the TCE plume, apparently located in advance (ie. downgradient) of the landfill chloride plume, the additional monitoring wells recommended above would also enable investigation of the extent of TCE migration. Pending the results of analyses performed on the wells installed for tracking the chloride plume, additional wells may be required to track the TCE plume.

Future Groundwater Monitoring

A reduction in the frequency of monitoring and number of locations to be monitored in the future is warranted, as discussed previously. Because there are no apparent seasonal fluctuations in the historical data trends, monitoring during particular times of the year does not appear important. Also, because most locations appear to exhibit relatively predictable trends, monitoring on a semi–annual basis is warranted for most locations. Other locations, where large parameter concentration increases have been reported recently or where key changes appear possible, should be monitored more frequently (quarterly). Pursuant to these comments, the following program is recommended:

LOCATIONS	FREQUENCY	Rational
Upgradient		
BH13–I	Semi–Annual	Background (Shallow)
BH13–II	Semi–Annual	Background (Intermediate)
Downgradient / At Landfill		
OW6s	Quarterly	Central Landfill (Shallow)
BHB–III	Semi–Annual	Central Landfill (Shallow–Int.)
BHB–II	Semi–Annual	Central Landfill (Int.–Deep)
BHA–III	Quarterly	South Landfill (Shallow)
BHA–II	Semi–Annual	South Landfill (Int.)
BHA–I	Semi–Annual	South Landfill (Deep)
BHC–III	Semi–Annual	North Landfill (Shallow)
BHC–I	Semi–Annual	North Landfill (Deep)
Downgradient / Above, Below or Within Plume Core		
BH12–II	Semi–Annual	Spatial (Intermediate)
BH7–I	Semi–Annual	Axis (Intermediate)
OW12s	Semi–Annual	Axis (Shallow)
OW12d	Quarterly	Axis (Shallow–Int.)
BH5–II	Semi–Annual	Spatial (Intermediate)
BH5–I	Semi–Annual	Spatial (Deep)
BH9–II	Semi–Annual	Axis (Shallow)
BH9–II	Quarterly	Axis (Intermediate)
BH9–I	Semi–Annual	Axis (Deep)
PL1	Quarterly	Axis (Intermediate)

Downgradient / Plume Edge

OW10s	Semi–Annual	East Edge (Shallow)
OW11s	Semi–Annual	East Edge (Shallow)
BH8–I	Semi–Annual	East Edge (Intermediate)
BH4–II	Semi–Annual	West Edge (Shallow)
OW15d	Semi–Annual	West Edge (Intermediate)
OW16d	Semi–Annual	West Edge (Intermediate)

Downgradient / Leading Edge

PL2	Quarterly	West Edge (Intermediate)
PL3	Quarterly	Central (Intermediate)

The above schedule includes seven (7) key wells monitored quarterly and twenty–one (21) wells monitored semi–annually, for a total of 28 locations. This is down from the 39 monitored previously. Any additional installed wells at the leading edge should be monitored on a quarterly basis initially until chemical trends are established.

As well, private domestic wells located downgradient of the present plume location (and in the depth range of the main aquifer) should be considered for inclusion in future monitoring events. Those private wells currently monitored and are no longer used for domestic purposes do not require further monitoring.

Water Level Monitoring

Water levels at all of the installed locations (including those not sampled) should be taken once per year and water levels should be taken during all quarterly monitoring events at the sampled wells.

Chemical Analysis

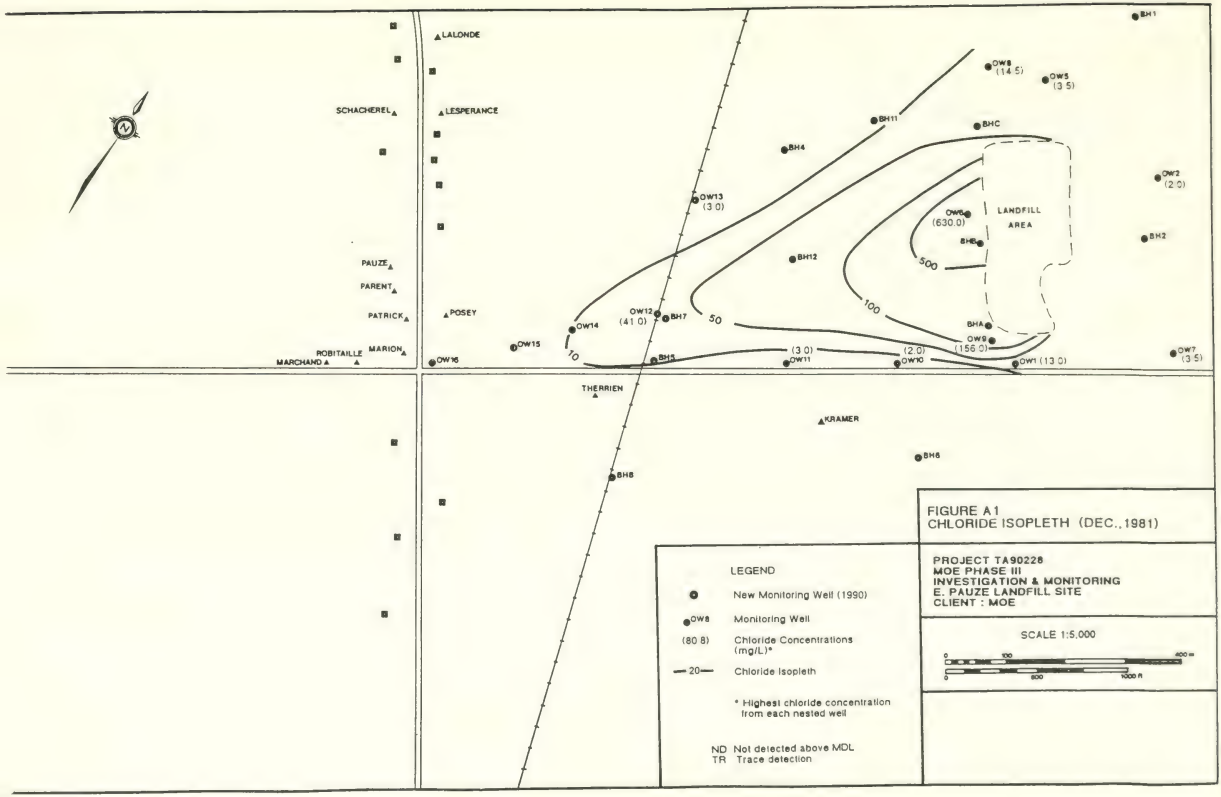
Plume definition would be adequately characterized by analysis of a target group of parameters including chloride, conductivity, pH, chemical oxygen demand, phenols and a VOC scan. The VOC scan should include the standard MISA 16 (halogenated) and 17 (aromatic) lists as well as chloroethane and methyl ethyl ketone.

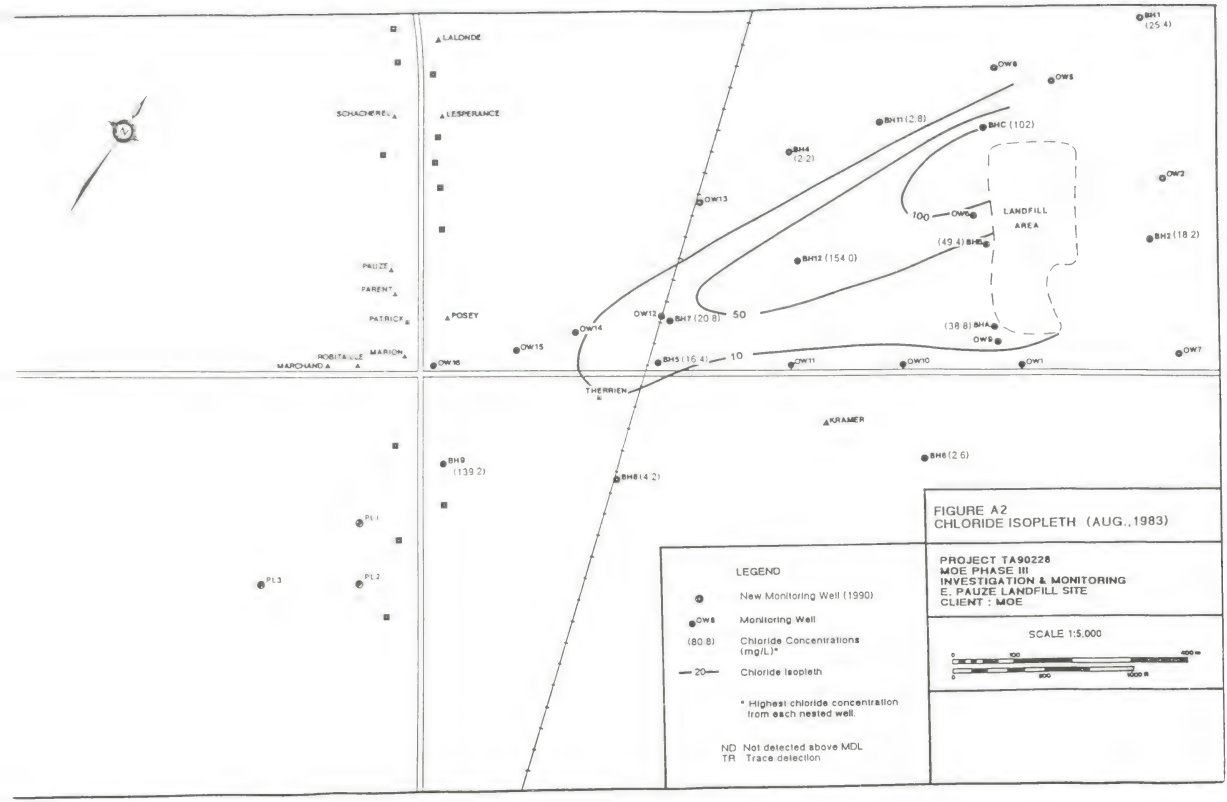
Monitoring Data Review

A yearly review of monitoring data should be conducted. This should include an update of plume configurations, analysis of chemical trends at individual locations, analysis of aquifer potentiometric surface, and recommendations for future monitoring program changes. Such a review is pertinent if the aforementioned changes to the program are adopted. In other words, the monitoring program must respond to the changes in groundwater impact.

APPENDIX A

CHLORIDE ISOPLETHS AND GRAPHS


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
OW16
OW15
OW14
OW12
(41.0)
BH7
BH5
OW13
(3.0)
BH4
BH11
BHC
OW8
(14.5)
OW5
(3.5)
BH1
OW2
(2.0)
BH2
OW6
(630.0)
LANDFILL
AREA
BH3
BH12
BHA
OW9
(156.0)
OW10
(2.0)
OW11
(3.0)
OW1 (13.0)
OW7
(3.5)
500
100
50
10
THERRIEN
KRAMER
BH6
BH8
LEGEND
New Monitoring Well (1990)
OW8 Monitoring Well
(80.8) Chloride Concentrations (mg/L)*
20 Chloride Isopleth
* Highest chloride concentration from each nested well
ND Not detected above MDL
TR Trace detection
FIGURE A1
CHLORIDE ISOPLETH (DEC., 1981)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 500 1000 ft


LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
BH1 (25.4)
OW8
OW9
BH11 (2.8)
BHC (102)
BH4 (2.2)
OW13
OW2
100
OW6
LANDFILL AREA
(49.4) BH3
BH12 (154.0)
BH2 (18.2)
OW12
BH7 (20.8)
50
OW14
(38.8) BHA
OW5
OW15
OW16
BH5 (16.4)
10
OW11
OW10
OW1
OW7
BH9 (139.2)
BH8 (4.2)
BH6 (2.6)
PL1
PL3
PL2
LEGEND
New Monitoring Well (1990)
OW8 Monitoring Well
(80.8) Chloride Concentrations (mg/L)*
20 Chloride Isopleth
* Highest chloride concentration from each nested well.
ND Not detected above MDL
TR Trace detection
FIGURE A2
CHLORIDE ISOPLETH (AUG., 1983)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
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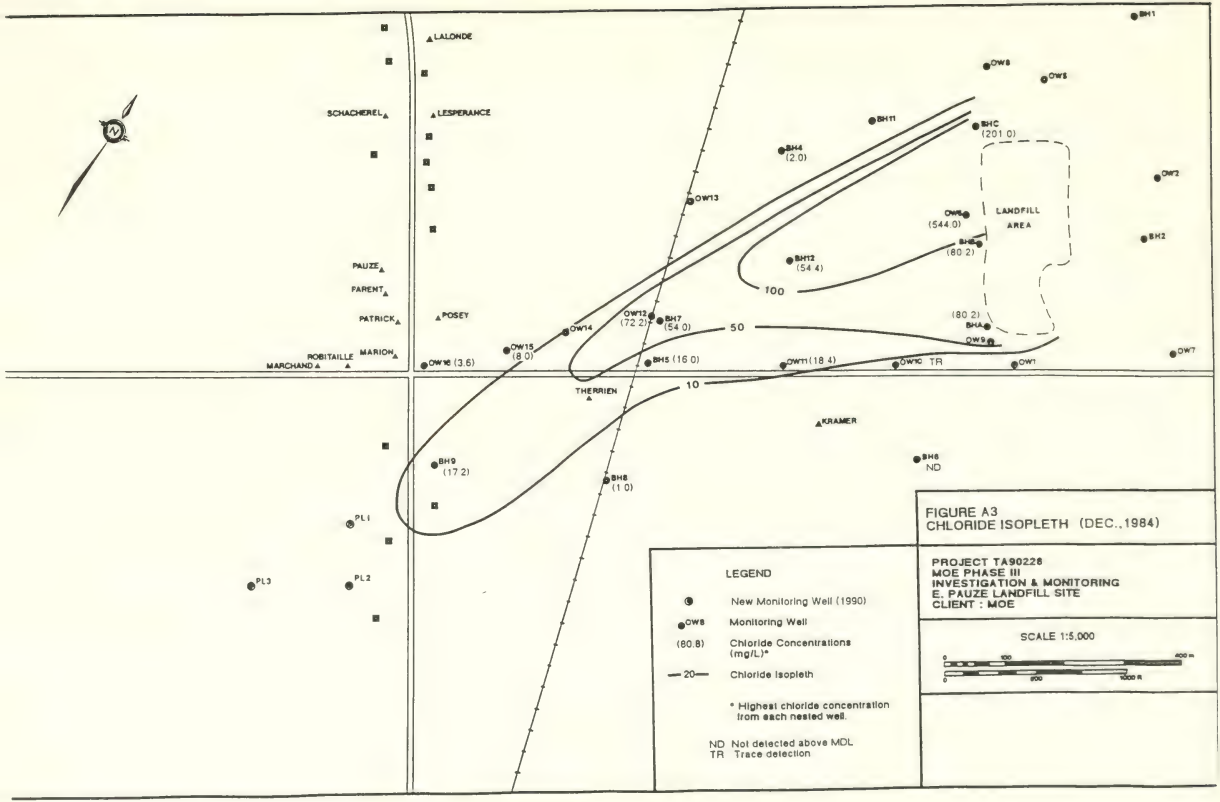
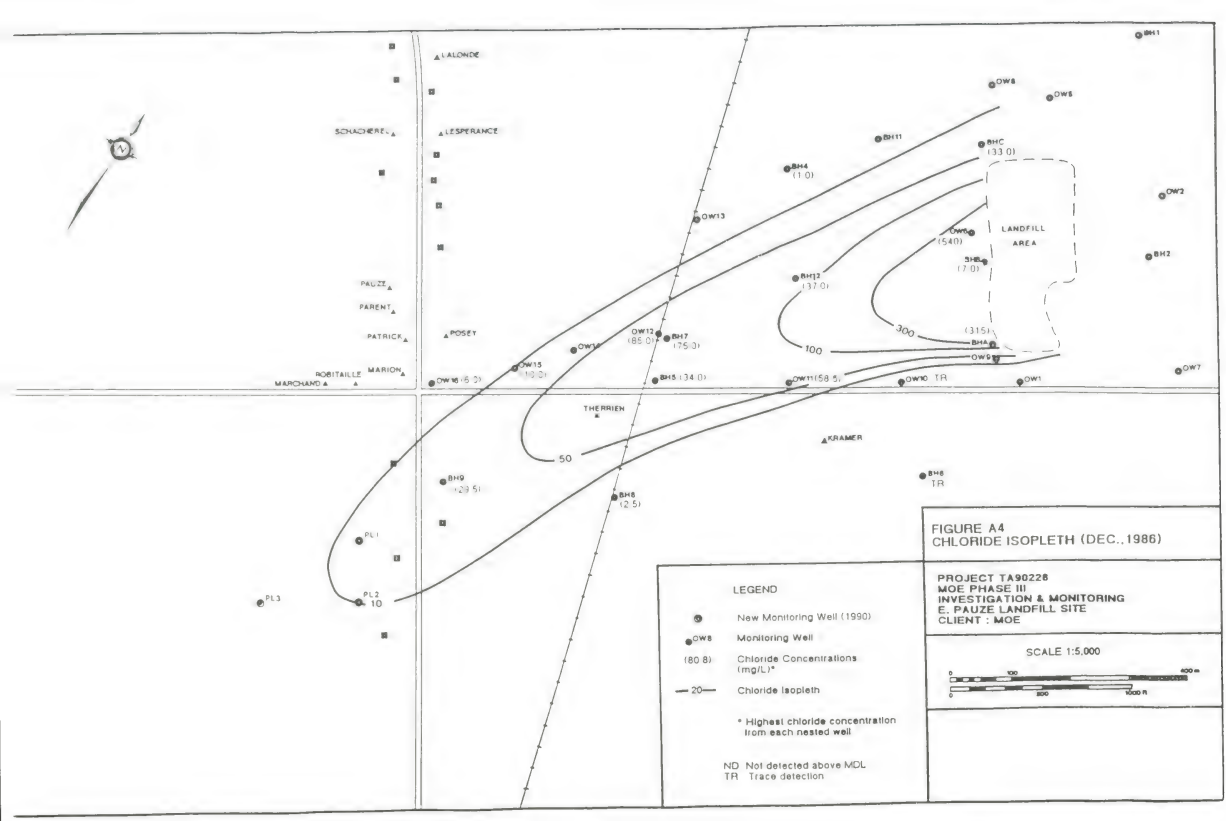
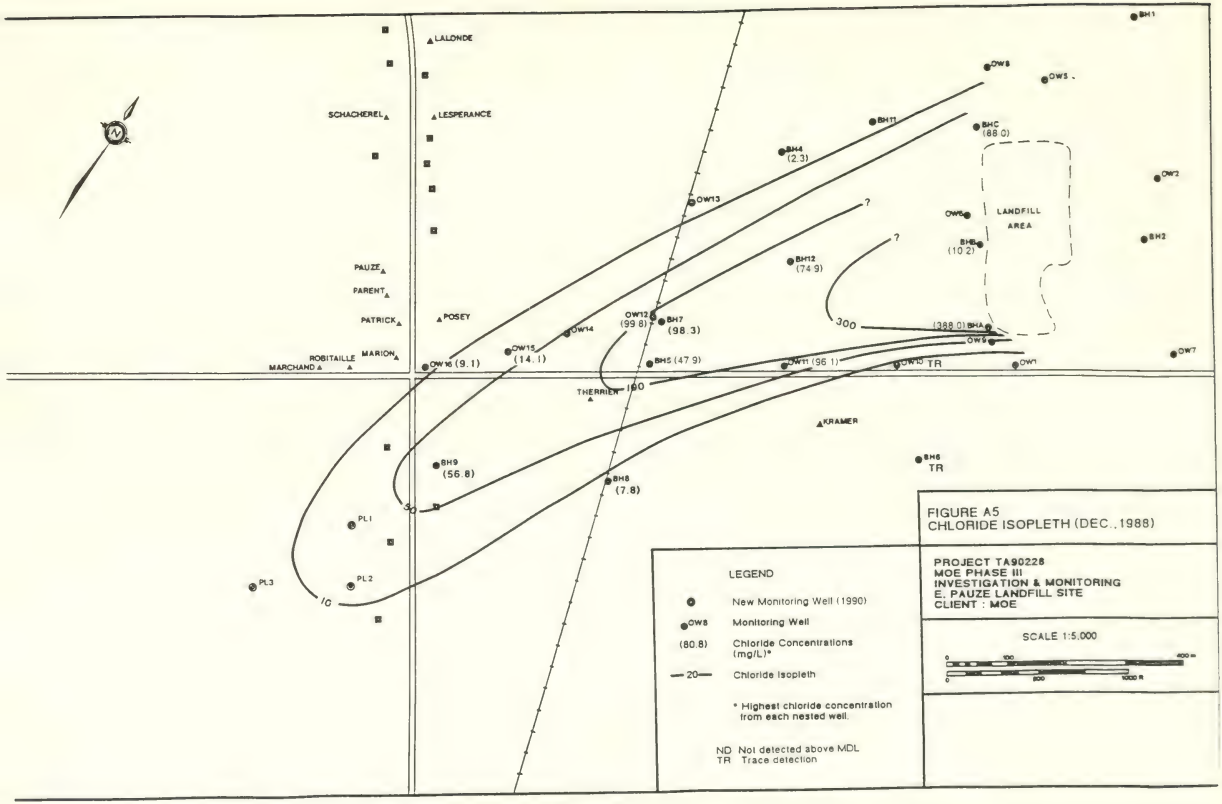
0 800 1600 ft


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARCHAND
MARION
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3
BH4 (2.0)
BH5 (16.0)
BH6 ND
BH7 (54.0)
BH8 (1.0)
BH9 (17.2)
BH10 (80.2)
BH11
BH12 (54.4)
BHC (201.0)
OW1
OW2
OW3
OW4
OW5
OW6 (3.6)
OW7
OW8
OW9 (544.0)
OW10 TR
OW11 (18.4)
OW12 (72.2)
OW13
OW14
OW15 (8.0)
PL1
PL2
PL3
100
50
10
FIGURE A3
CHLORIDE ISOPLETH (DEC., 1984)
LEGEND
New Monitoring Well (1990)
OW8 Monitoring Well
(80.8) Chloride Concentrations (mg/L)*
20 Chloride Isopleth
* Highest chloride concentration from each nested well.
ND Not detected above MDL
TR Trace detection
PROJECT TA90226
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 500 1000 ft


LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
OW8
OW5
BH1
BH11
BHC (33.0)
BH4 (1.0)
OW2
OW13
OW6 (540)
LANDFILL AREA
BH2
BH5 (7.0)
BH12 (37.0)
OW12 (85.0)
BH7 (75.0)
OW14
OW15 (12.2)
OW16 (6.2)
BH3 (34.0)
OW11 (58.5)
OW10 TR
OW1
OW7
BHA (315)
OW9
300
100
50
10
BH9 (29.5)
BH8 (2.5)
BH6 TR
PL1
PL2
PL3
N
FIGURE A4
CHLORIDE ISOPLETH (DEC., 1986)
LEGEND
New Monitoring Well (1990)
OW8 Monitoring Well
(80.8) Chloride Concentrations (mg/L)*
20 Chloride Isopleth
* Highest chloride concentration from each nested well
ND Not detected above MDL
TR Trace detection
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 200 1000 ft


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
OW8
OW5
BH11
BHC (88.0)
BH4 (2.3)
OW13
OW2
OW6
BH3 (10.2)
BH12 (74.9)
BH2
OW12 (99.8)
BH7 (98.3)
OW14
OW15 (14.1)
OW16 (9.1)
BH5 (47.9)
OW11 (96.1)
OW10 TR
OW9
OW1
OW7
BHA (388.0)
300
100
50
10
BH9 (56.8)
BH8 (7.8)
BH6 TR
PL1
PL2
PL3
FIGURE A5
CHLORIDE ISOPLETH (DEC., 1988)
LEGEND
New Monitoring Well (1990)
OW8 Monitoring Well
(80.8) Chloride Concentrations (mg/L)*
20 Chloride Isopleth
* Highest chloride concentration from each nested well.
ND Not detected above MDL
TR Trace detection
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 200 m
0 500 1000 ft

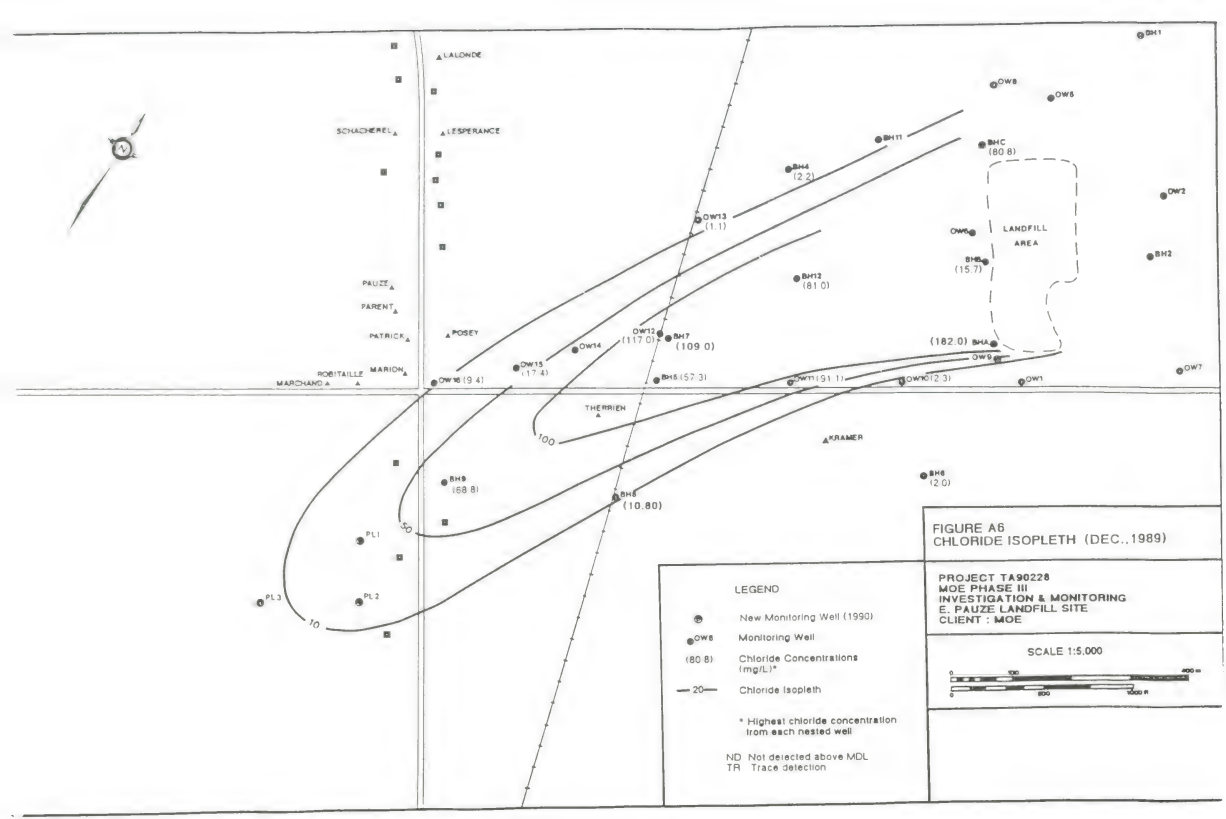


FIGURE A6
CHLORIDE ISOPLETH (DEC.,1989)

LEGEND

- New Monitoring Well (1990)
- OW5 Monitoring Well
- (80.8) Chloride Concentrations (mg/L)*
- —20— Chloride Isopleth

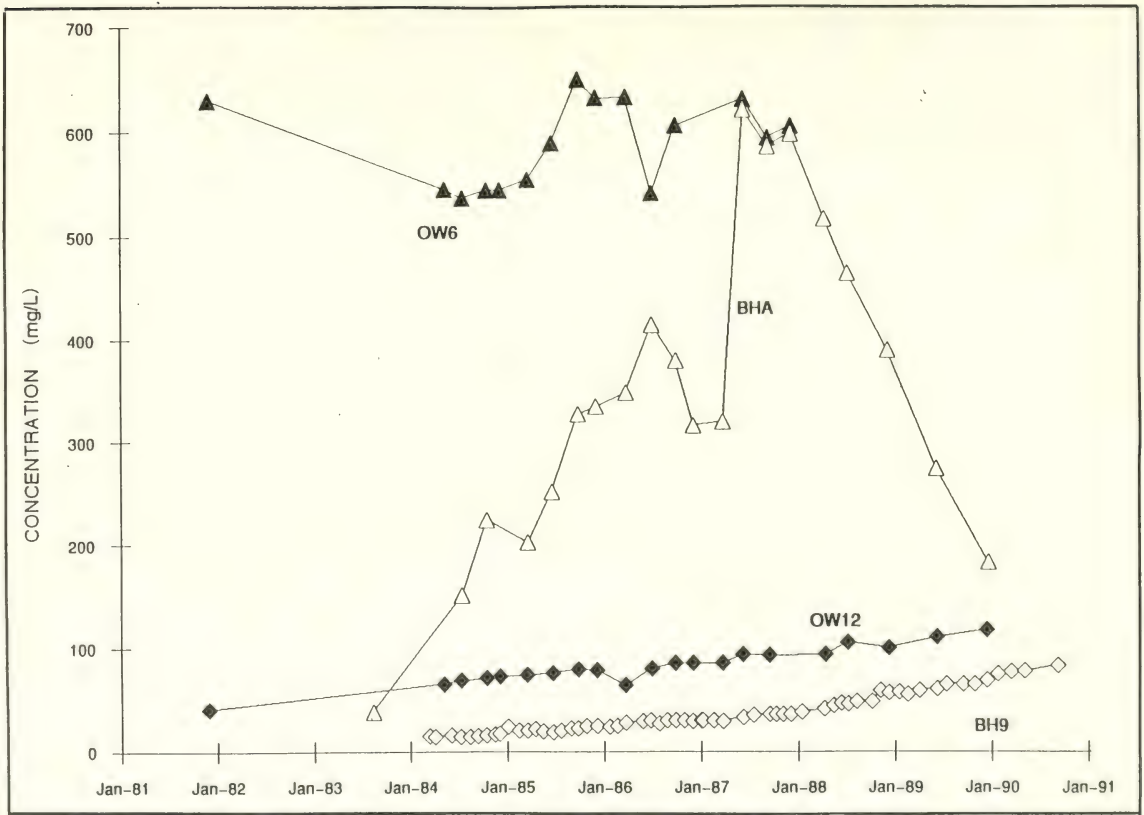
* Highest chloride concentration from each nested well

ND Not detected above MDL
TR Trace detection

PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

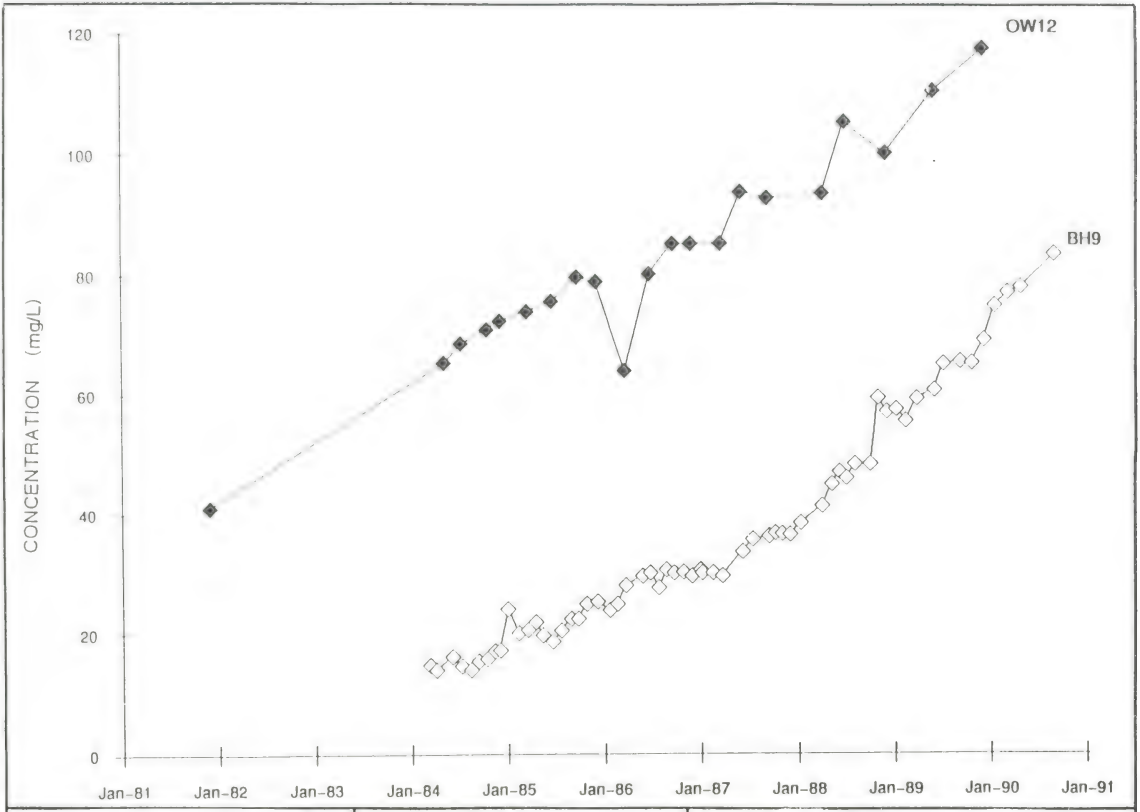
SCALE 1:5,000

0 100 400 m
0 800 1600 ft



PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

FIGURE A7
CHLORIDE CONCENTRATION VERSUS TIME FOR SELECTED WELLS

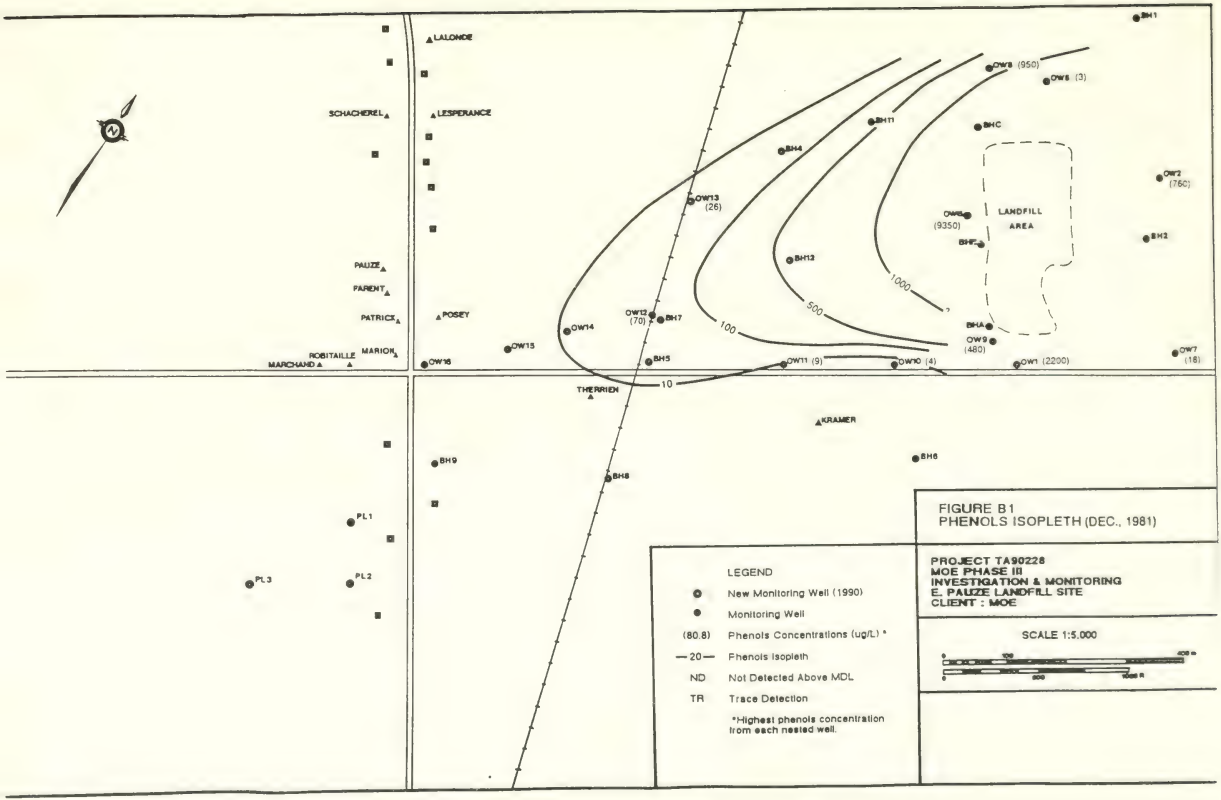


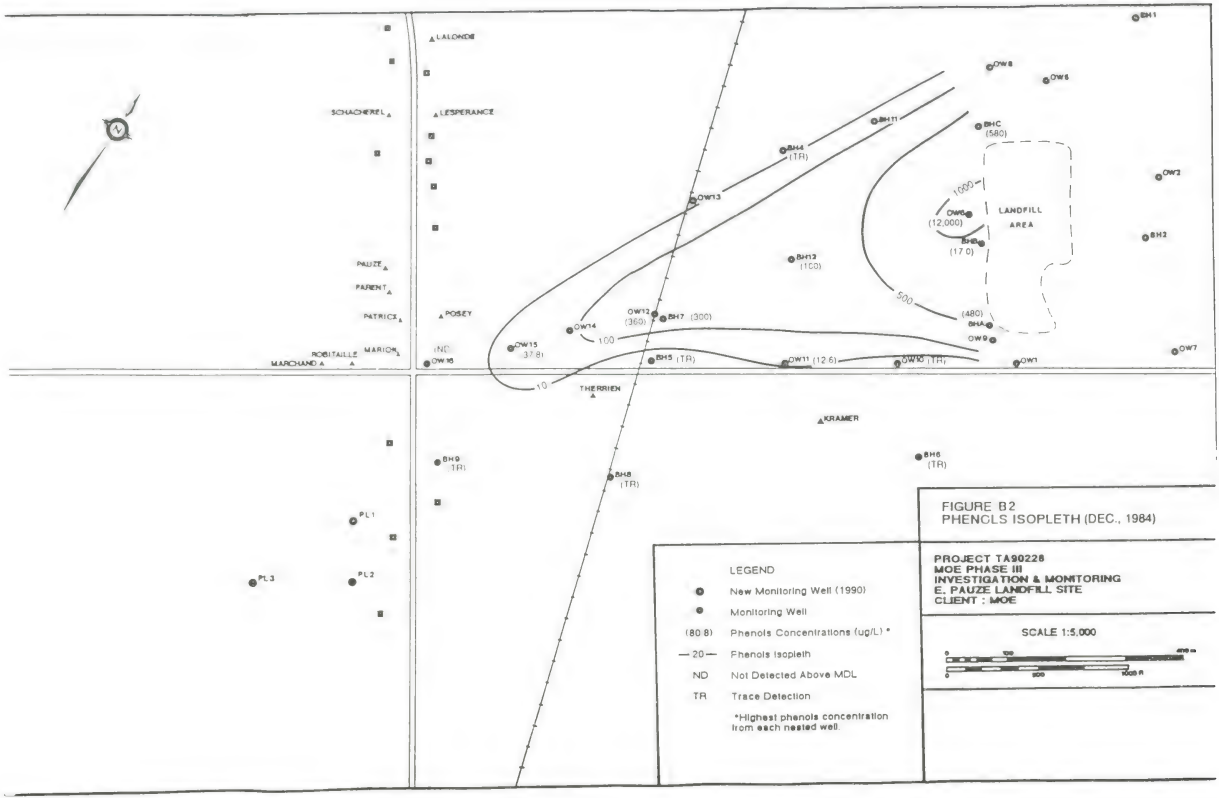
PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

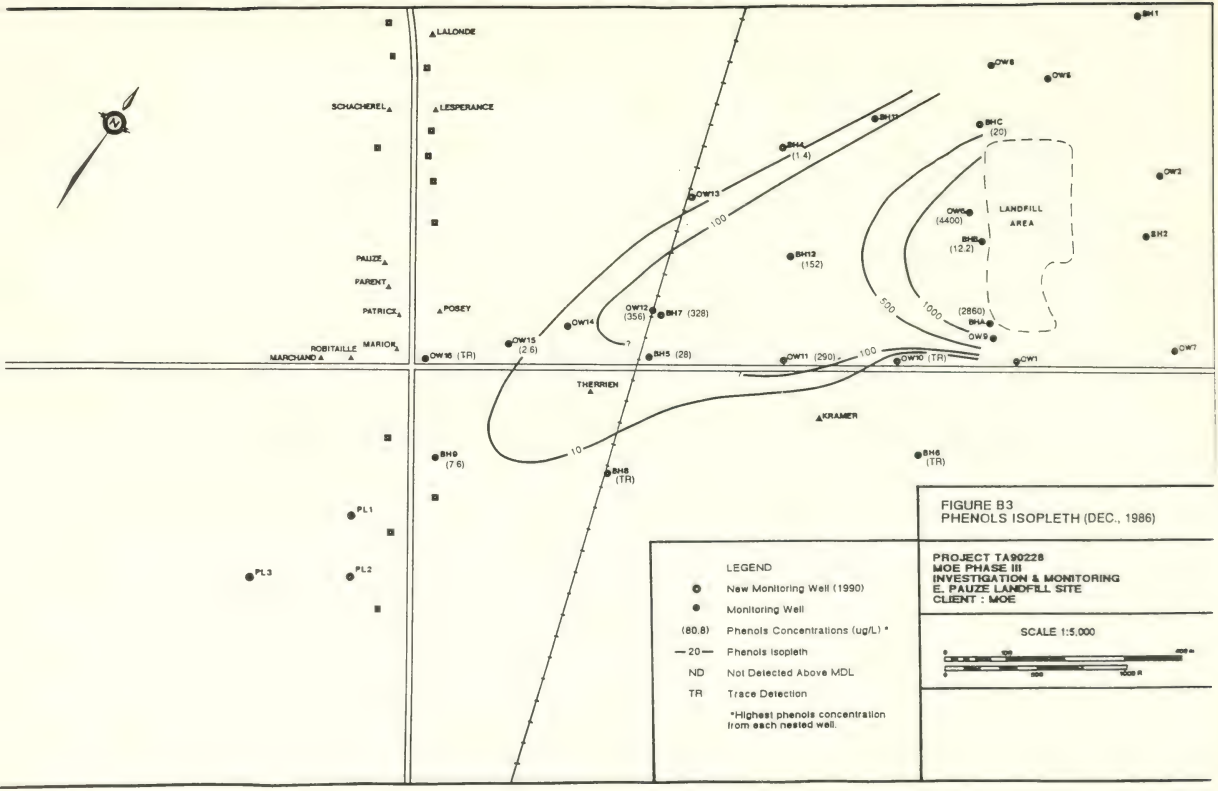
FIGURE A8
CHLORIDE CONCENTRATION VERSUS TIME
FOR WELLS OW12 AND BH9

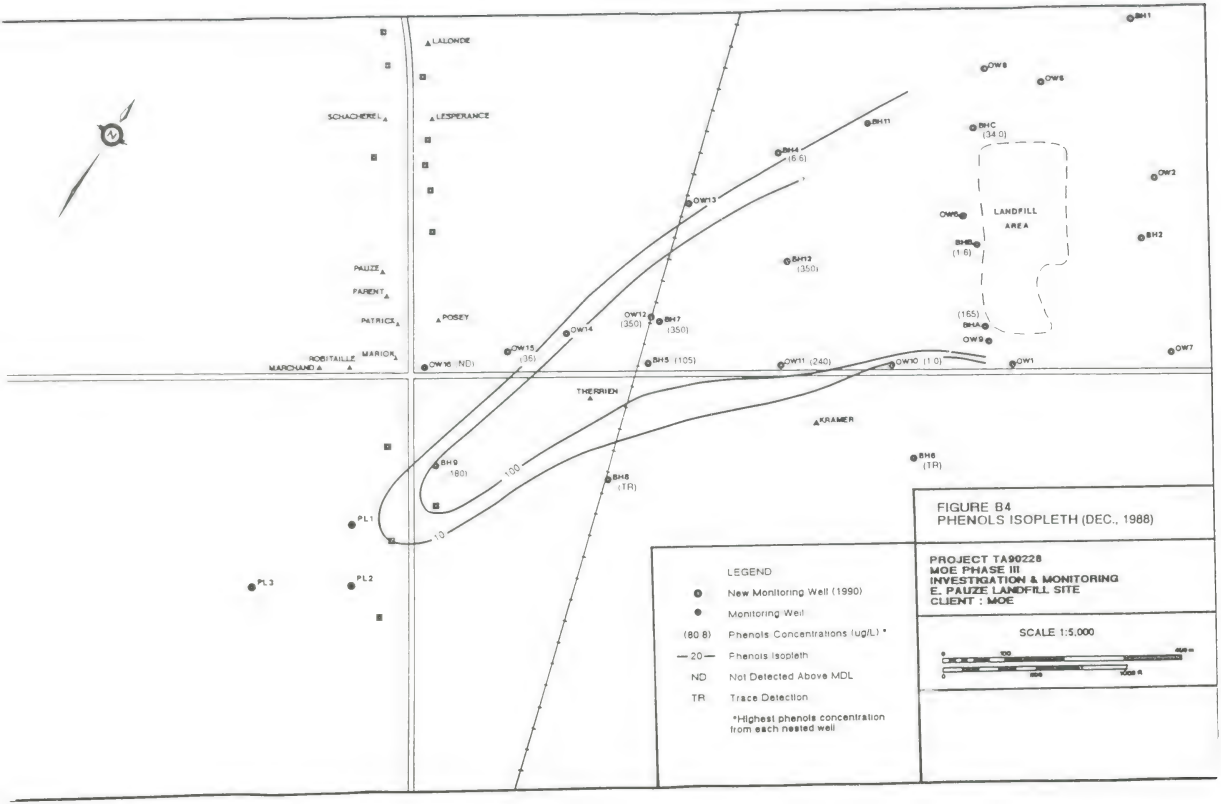
APPENDIX B

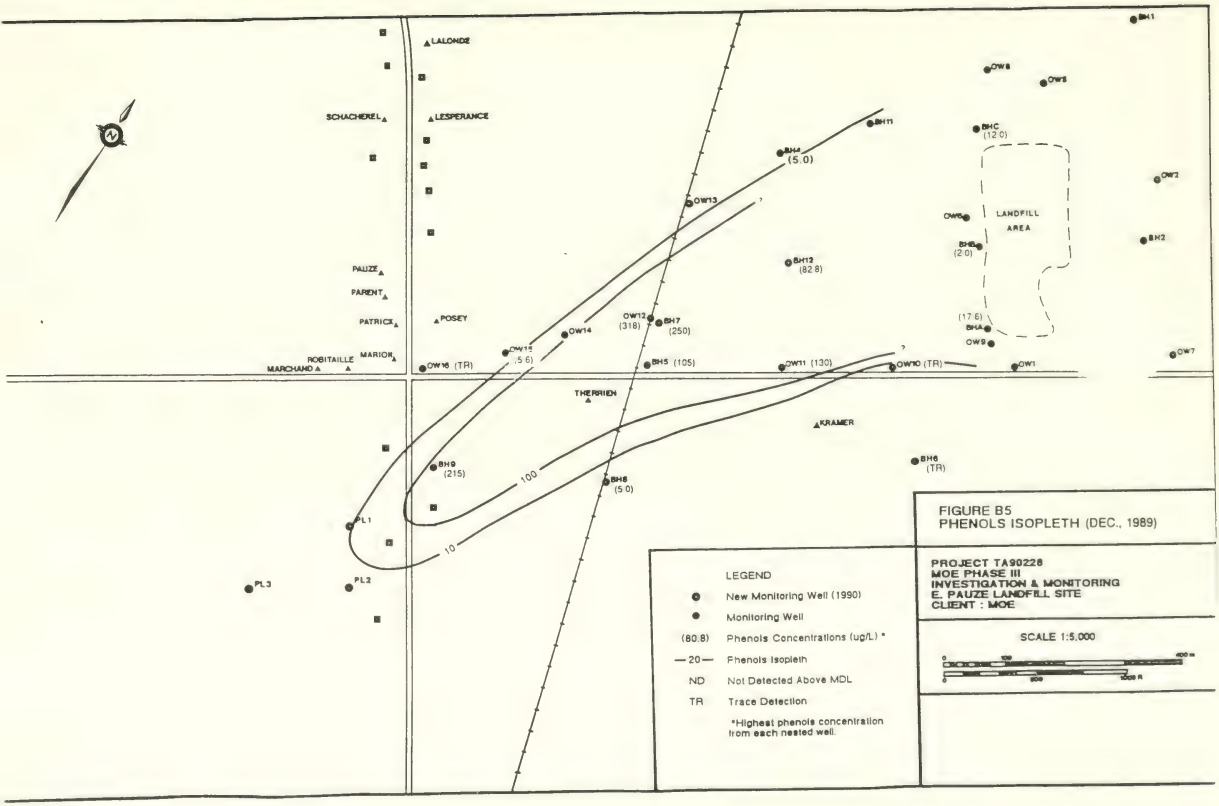
PHENOLS ISOPLETHS AND GRAPHS

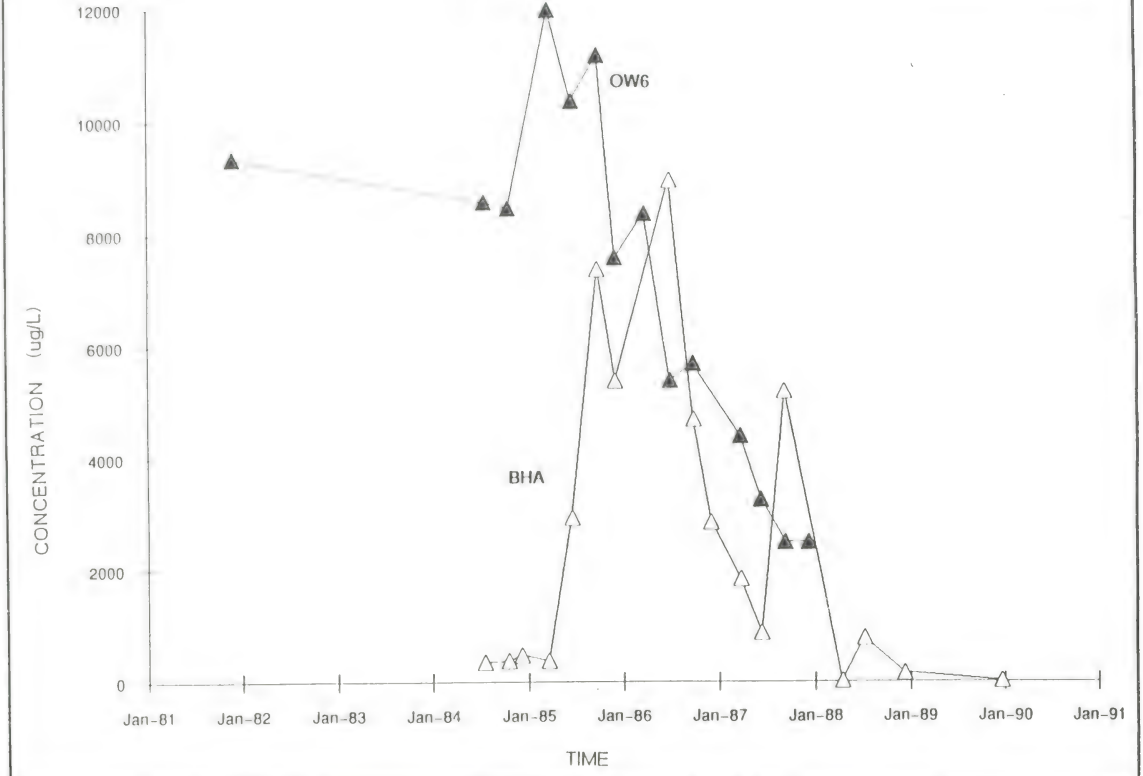

LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH1A
BH2
BH3
BH4
BH5
BH6
BH7
BH8
BH9
BH10
BH11
BH12
BH13
OW1 (2200)
OW2 (760)
OW3 (950)
OW4 (3)
OW5 (9350)
OW7 (18)
OW9 (480)
OW10 (4)
OW11 (9)
OW12 (70)
OW13 (26)
OW14
OW15
OW16
PL1
PL2
PL3
1000
500
100
10
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) Phenols Concentrations (ug/L) *
—20— Phenols Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest phenols concentration from each nested well.
FIGURE B1
PHENOLS ISOPLETH (DEC., 1981)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICE
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3 (TR)
BH4 (TR)
BH5 (TR)
BH6 (TR)
BH7 (300)
BH8 (TR)
BH9 (TR)
BH10 (480)
BH11
BH12 (100)
BH13 (100)
BHC (580)
OW1
OW2
OW3
OW4 (17.0)
OW5 (12,000)
OW6
OW7
OW8
OW9
OW10 (TR)
OW11 (12.6)
OW12 (360)
OW13
OW14
OW15 (37.8)
OW16 (ND)
PL1
PL2
PL3
1000
500
100
10
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) Phenols Concentrations (ug/L) *
—20— Phenols Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest phenols concentration from each nested well.
FIGURE B2
PHENOLS ISOPLETH (DEC., 1984)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARCHAND
MARION
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH1A
BH2
BH3
BH4 (1.4)
BH5 (28)
BH6 (TR)
BH7 (328)
BH8 (TR)
BH9 (7.6)
BH10
BH11
BH12 (152)
BH13
BHC (20)
OW1
OW2
OW5
OW6 (4400)
OW7
OW8
OW9 (2860)
OW10 (TR)
OW11 (290)
OW12 (356)
OW13
OW14
OW15 (2.6)
OW16 (TR)
PL1
PL2
PL3
10
100
500
1000
?
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80,8) Phenols Concentrations (ug/L) *
20 Phenols Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest phenols concentration from each nested well.
FIGURE B3
PHENOLS ISOPLETH (DEC., 1986)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000

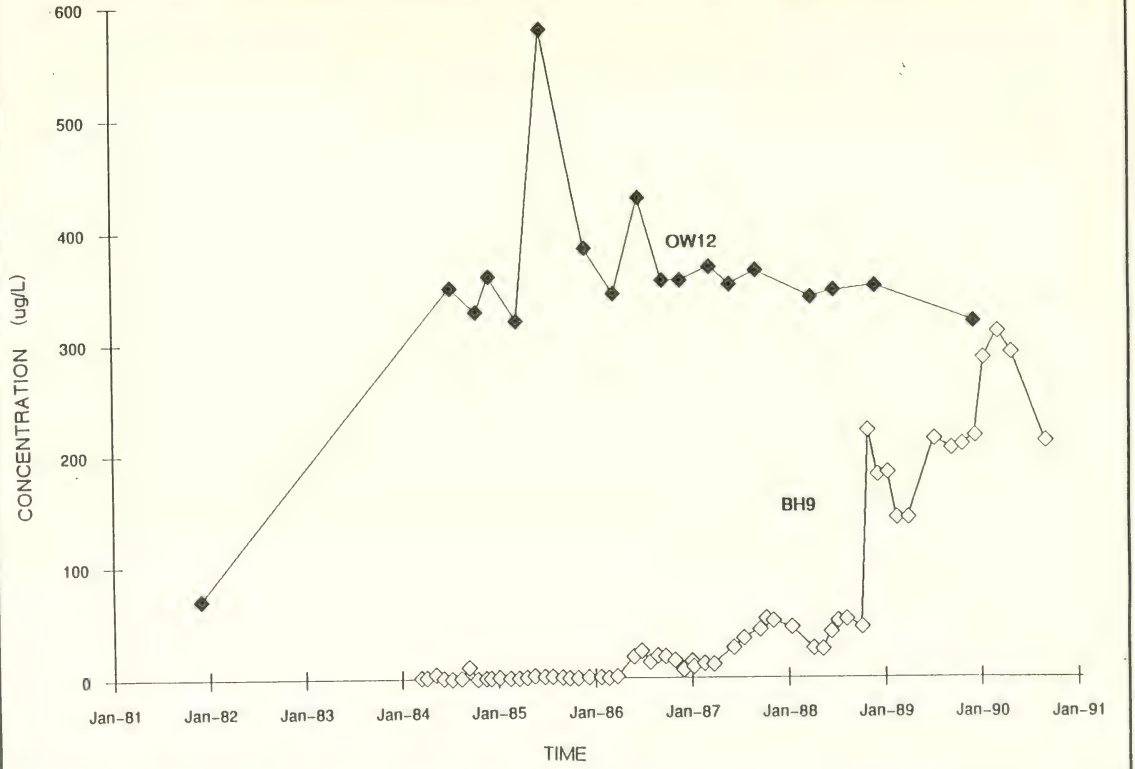

LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
OW16 (ND)
OW15 (35)
OW14
OW12 (350)
BH7 (350)
OW13
BH5 (105)
OW11 (240)
OW10 (1.0)
OW1
OW9
BHA (165)
BHB (1.6)
BH12 (350)
BH4 (6.6)
BH11
BHC (34.0)
OW8
OW6
OW5
OW2
BH2
OW7
BH1
BH9 (180)
BH8 (TR)
BH6 (TR)
100
10
PL1
PL2
PL3
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) Phenols Concentrations (ug/L) *
—20— Phenols Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest phenols concentration from each nested well
FIGURE B4
PHENOLS ISOPLETH (DEC., 1988)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3 (2.0)
BH4 (17.6)
BH5 (105)
BH6 (TR)
BH7 (250)
BH8 (5.0)
BH9 (215)
BH10 (12.0)
BH11
BH12 (82.8)
BH13 (5.0)
OW1
OW2
OW3
OW4
OW5
OW6
OW7
OW8
OW9
OW10 (TR)
OW11 (130)
OW12 (318)
OW13
OW14
OW15 (5.6)
OW16 (TR)
PL1
PL2
PL3
100
10
N
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) Phenols Concentrations (ug/L) *
—20— Phenols Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest phenols concentration from each nested well.
FIGURE B5
PHENOLS ISOPLETH (DEC., 1989)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
0 100 400 m
0 200 800 ft



PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

FIGURE B6
PHENOLS CONCENTRATION VERSUS TIME
FOR BHA and OW6

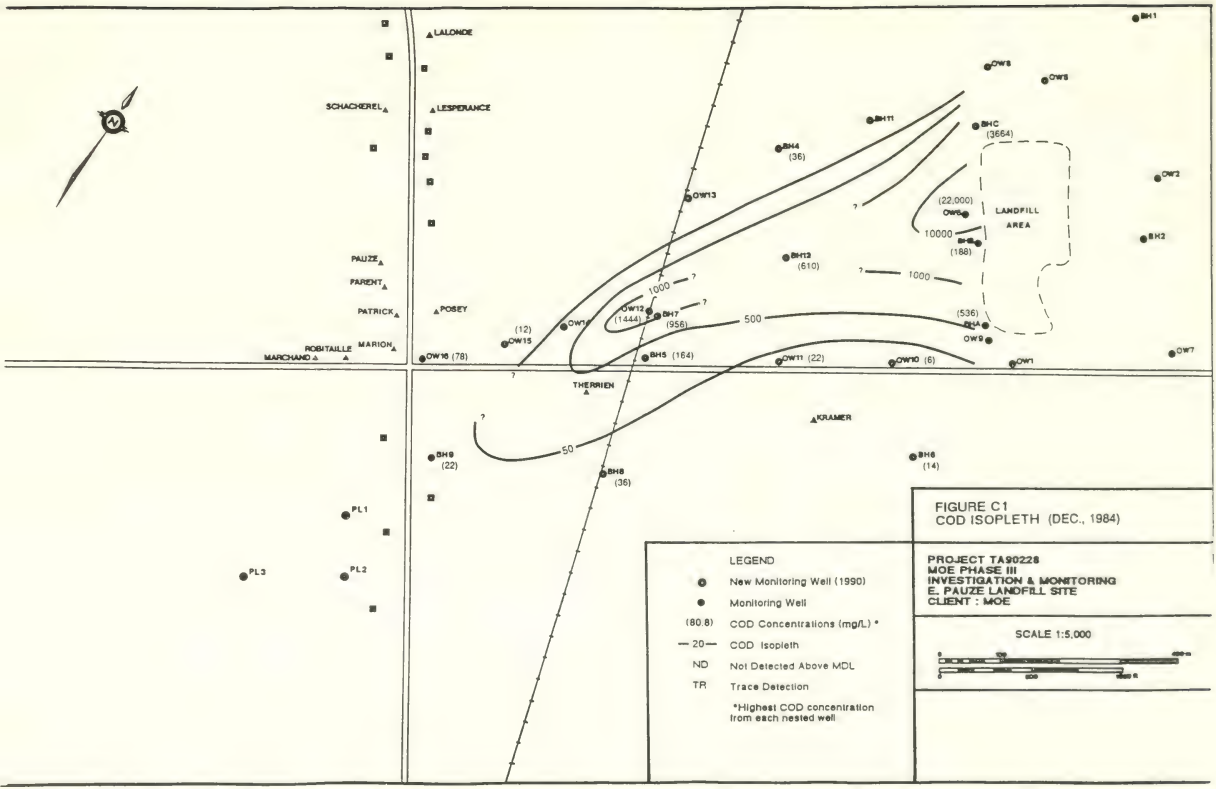


PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

FIGURE B7
PHENOLS CONCENTRATION VERSUS TIME
FOR OW12 and BH9

APPENDIX C

COD ISOPLETHS


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
PL1
PL2
PL3
BH1
BH2
BH3 (610)
BH4 (36)
BH5 (164)
BH6 (14)
BH7 (956)
BH8 (36)
BH9 (22)
BH10 (536)
BH11
BHC (3664)
OW1
OW2
OW5
OW6
OW7
OW8
OW9
OW10 (6)
OW11 (22)
OW12 (1444)
OW13
OW15 (12)
OW16 (78)
(22,000)
10000
(188)
LANDFILL AREA
1000
500
50
?
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) COD Concentrations (mg/L) *
— 20 — COD Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest COD concentration from each nested well
FIGURE C1
COD ISOPLETH (DEC., 1984)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000

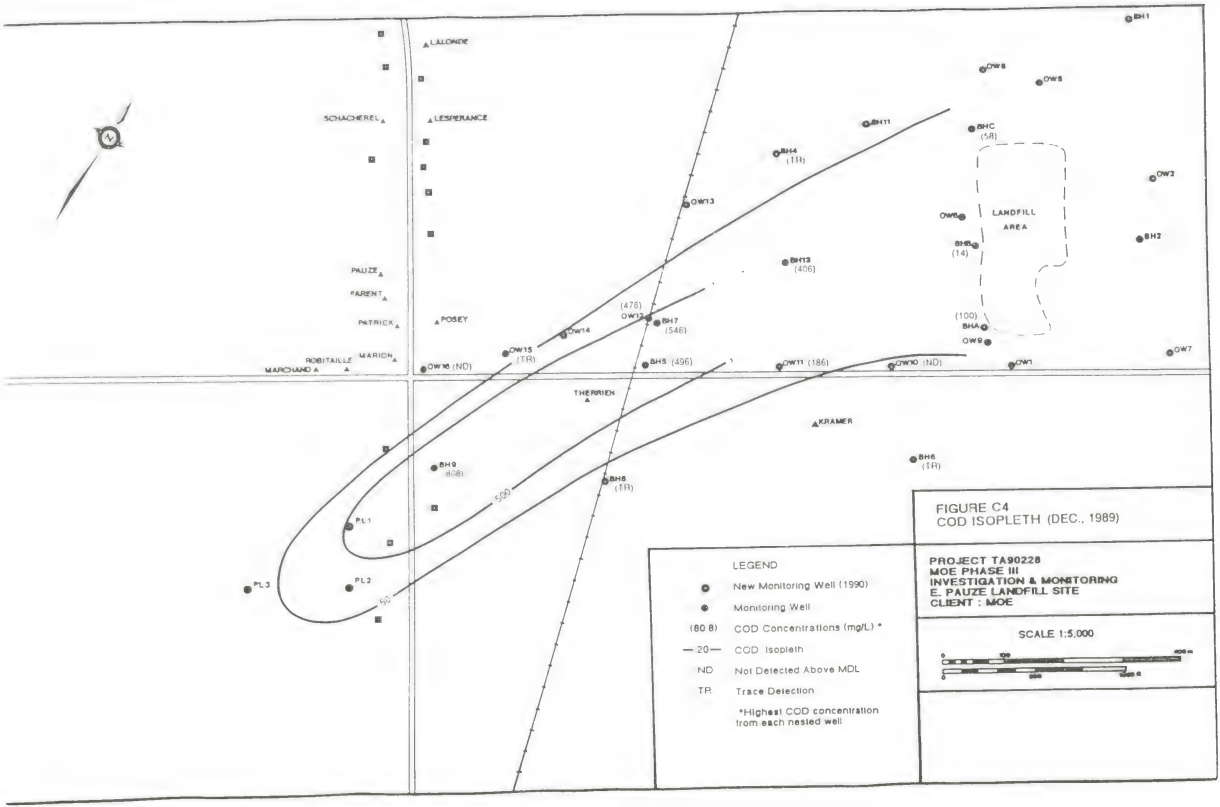


FIGURE C4
COD ISOPLETH (DEC., 1989)

PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

SCALE 1:5,000

0 100 400 m
0 200 800 ft

LEGEND

- New Monitoring Well (1990)
- Monitoring Well
- (80 8) COD Concentrations (mg/L) *
- — 20 — COD Isopleth
- ND Not Detected Above MDL
- TR Trace Detection

*Highest COD concentration from each nested well

APPENDIX D

TOLUENE ISOPLETHS AND GRAPHS

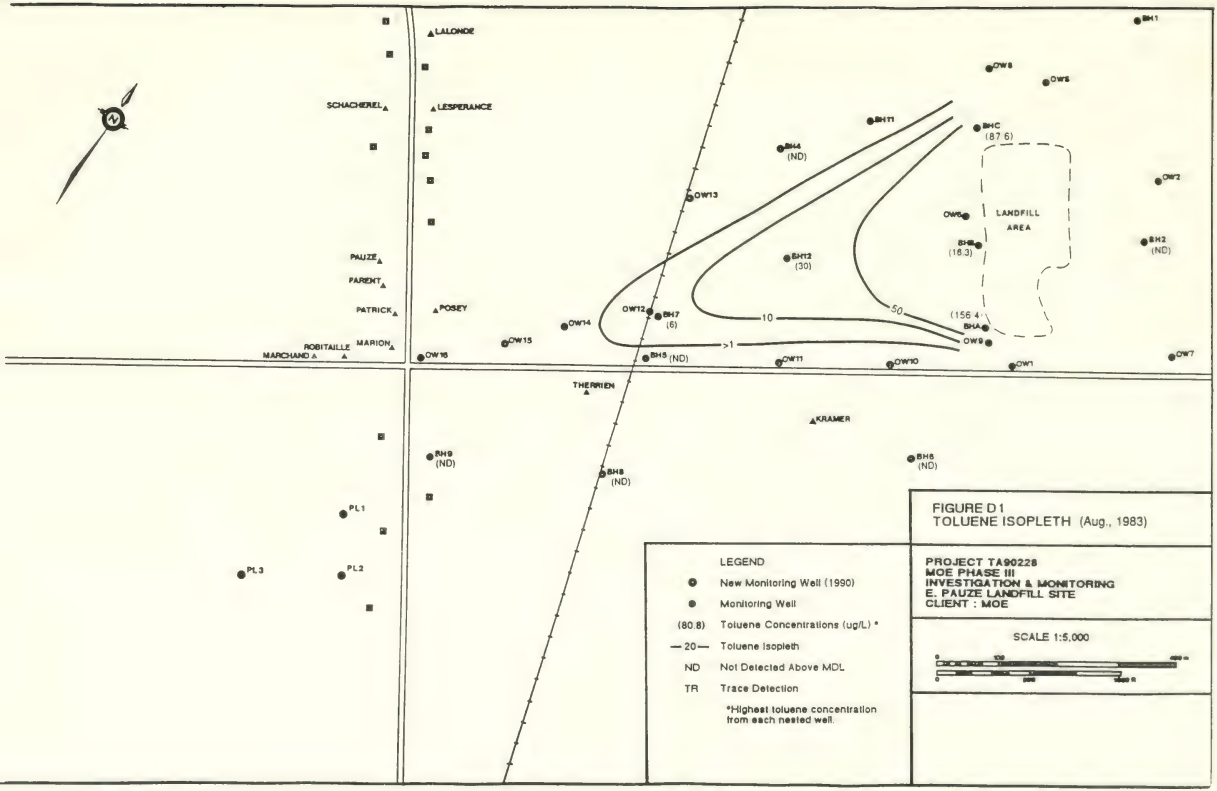


FIGURE D1
TOLUENE ISOPLETH (Aug., 1983)

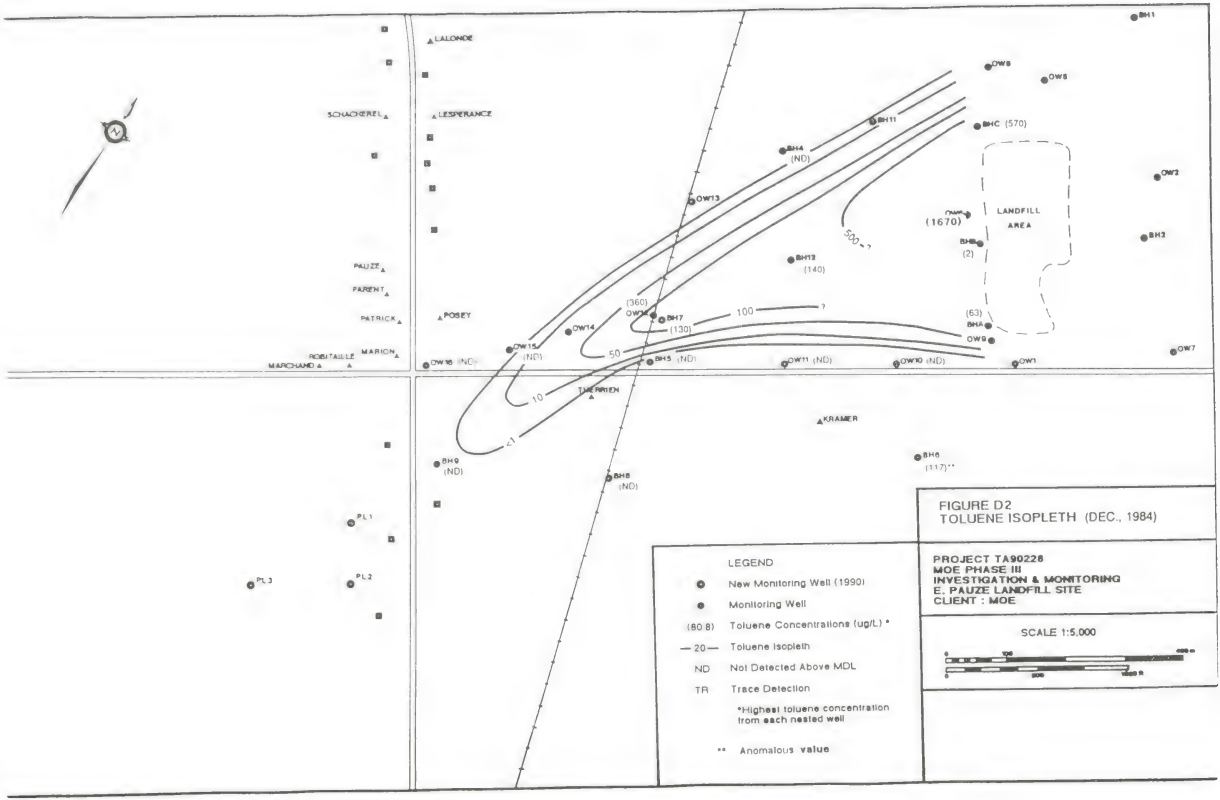
LEGEND

- New Monitoring Well (1990)
- Monitoring Well
- (80.8) Toluene Concentrations (ug/L) *
- — 20 — Toluene Isopleth
- ND Not Detected Above MDL
- TR Trace Detection

*Highest toluene concentration from each nested well.

PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
TAILPRIEN
KRAMER
LANDFILL AREA
BH1
OW8
OW8
BH11
BHC (570)
BH4 (ND)
OW2
OW13
(1670)
BH3
BH12 (140)
BH8 (2)
500
(360)
OW14
BH7 (130)
100
?
(63)
BHA
OW9
OW7
OW15 (ND)
50
BH5 (ND)
OW11 (ND)
OW10 (ND)
OW1
OW16 (ND)
10
1
BH9 (ND)
BH6 (ND)
BH6 (117)**
PL1
PL3
PL2
FIGURE D2
TOLUENE ISOPLETH (DEC., 1984)
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) Toluene Concentrations (ug/L) *
20 Toluene Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest toluene concentration from each nested well
** Anomalous value
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000

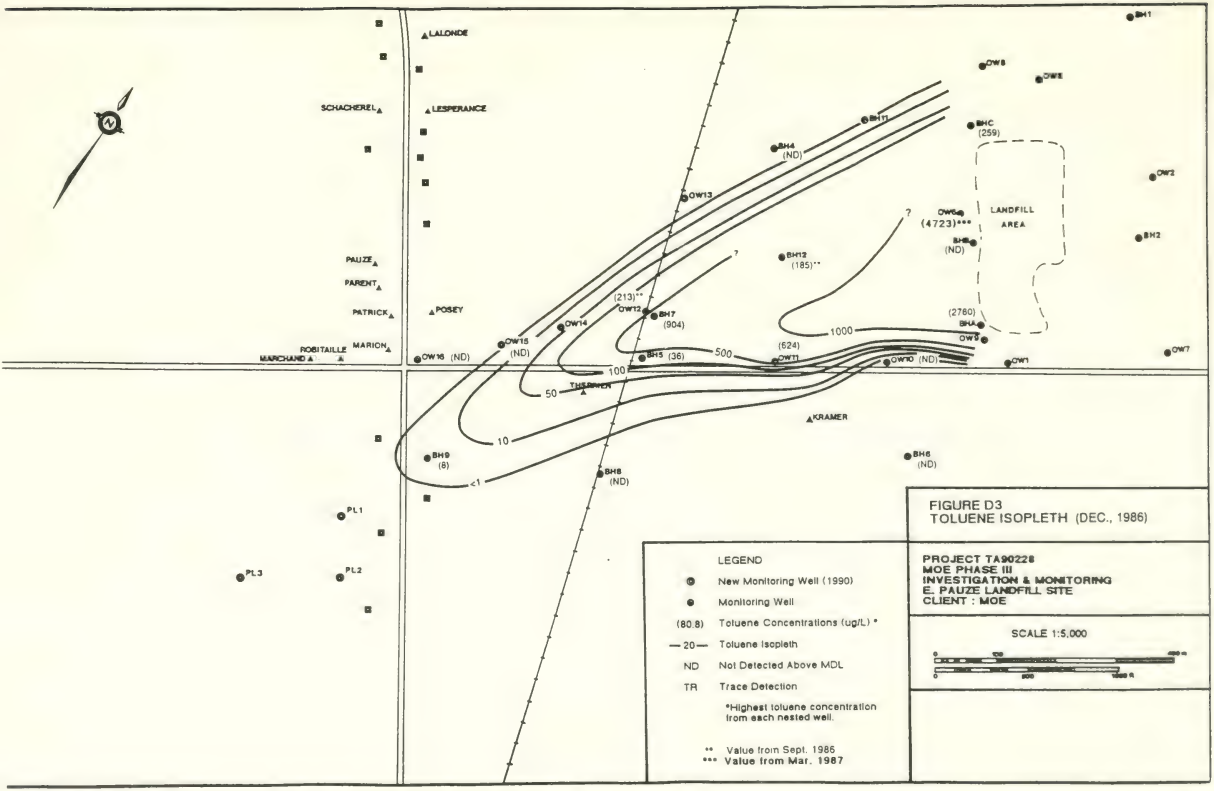


FIGURE D3
TOLUENE ISOPLETH (DEC., 1986)

LEGEND

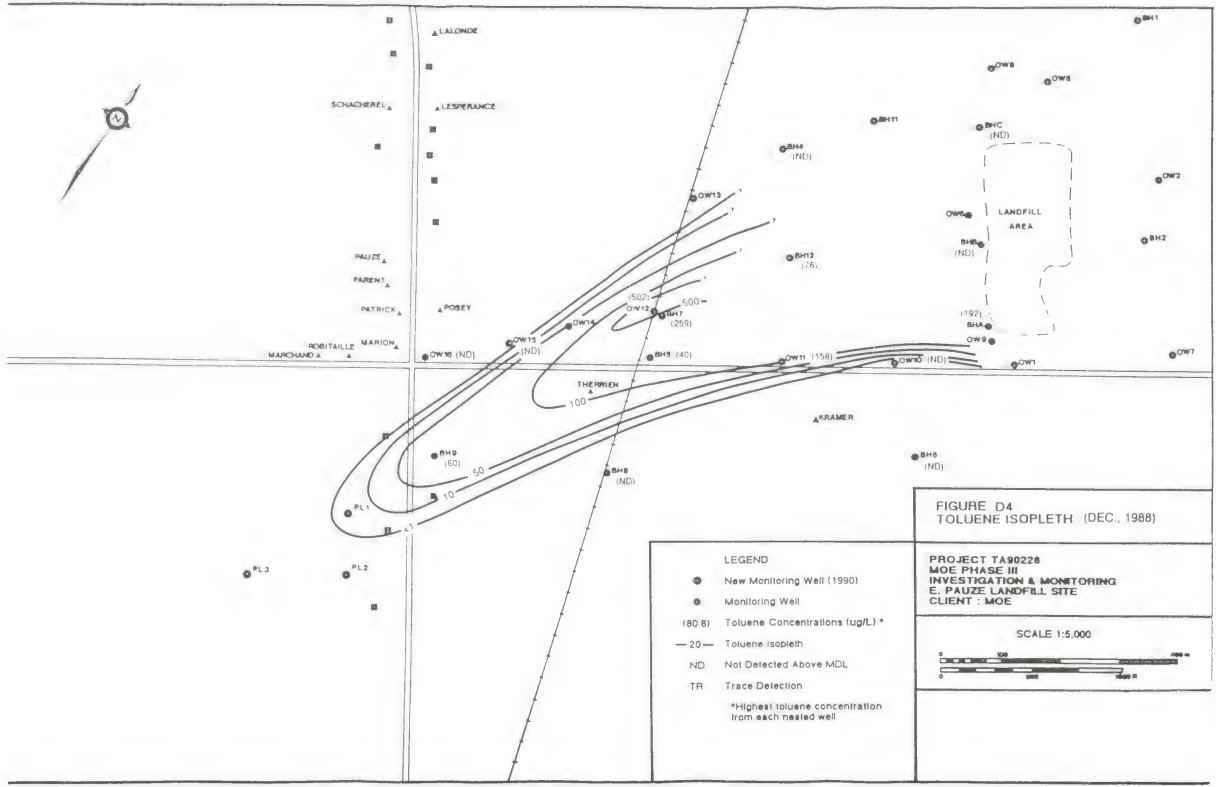
- New Monitoring Well (1990)
- Monitoring Well
- (80.8) Toluene Concentrations (ug/L) *
- — 20 — Toluene Isopleth
- ND Not Detected Above MDL
- TR Trace Detection

*Highest toluene concentration from each nested well.

** Value from Sept. 1985
*** Value from Mar. 1987

PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
OW16 (ND)
OW15 (ND)
OW14
OW13
OW12 (502)
BH7 (259)
BH9 (60)
BH8 (ND)
BH5 (40)
BH12 (76)
BH4 (ND)
BH11
BHC (ND)
BHB (ND)
BHA (192)
OW11 (158)
OW10 (ND)
OW9
OW8
OW6
OW1
OW2
OW7
BH1
BH2
BH6 (ND)
PL1
PL2
PL3
100
50
10
FIGURE D4
TOLUENE ISOPLETH (DEC., 1988)
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80/8) Toluene Concentrations (ug/L) *
20 Toluene Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest toluene concentration from each nested well
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000

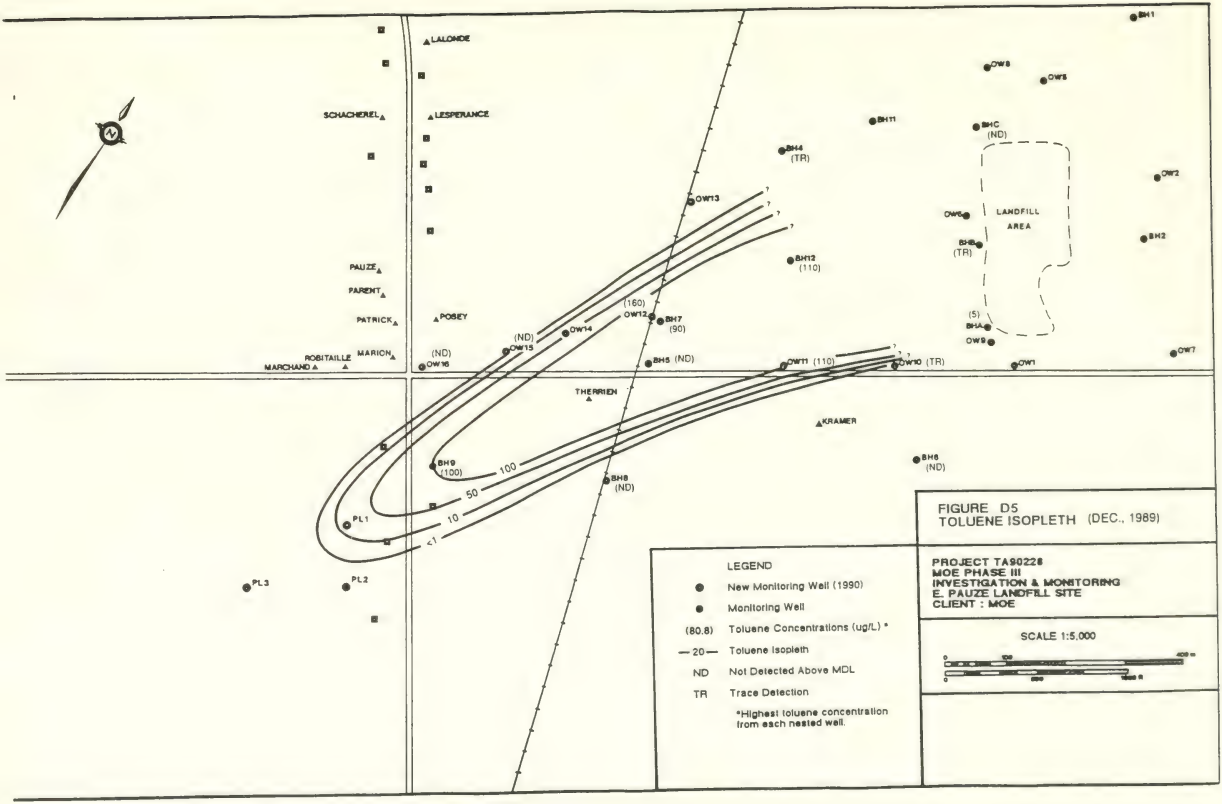


FIGURE D5
TOLUENE ISOPLETH (DEC., 1989)

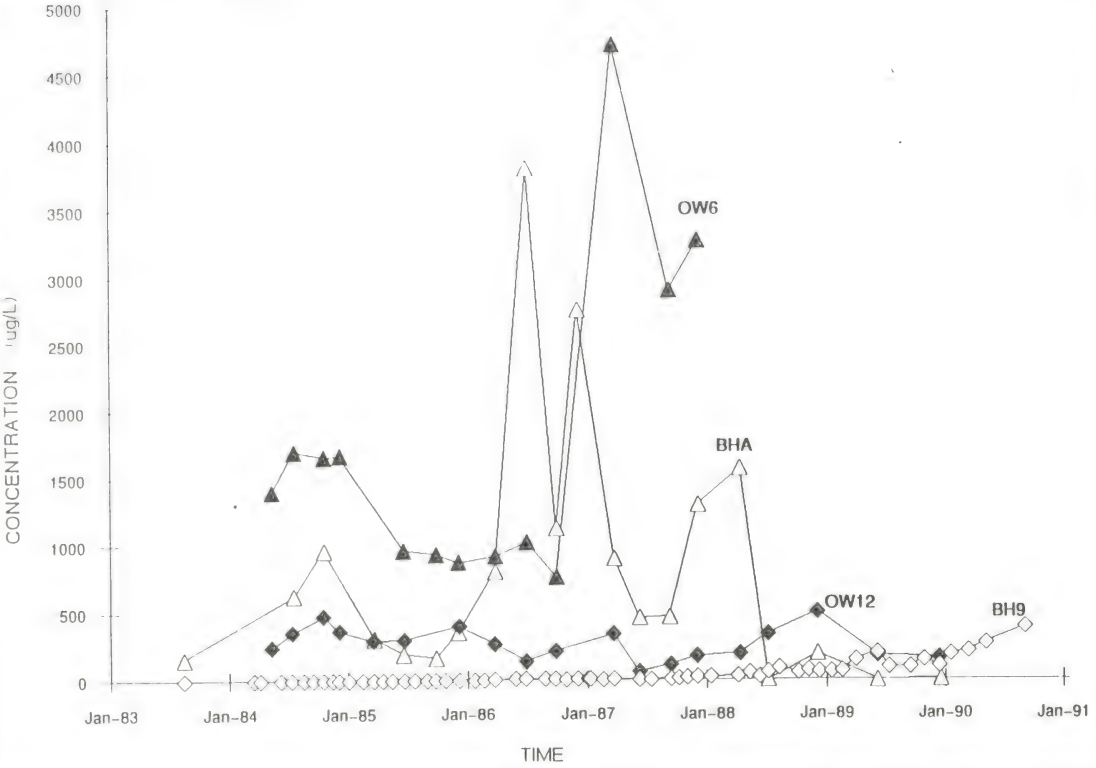
LEGEND

- New Monitoring Well (1990)
- Monitoring Well
- (80.8) Toluene Concentrations (ug/L) *
- —20— Toluene Isopleth
- ND Not Detected Above MDL
- TR Trace Detection

*Highest toluene concentration from each nested well.

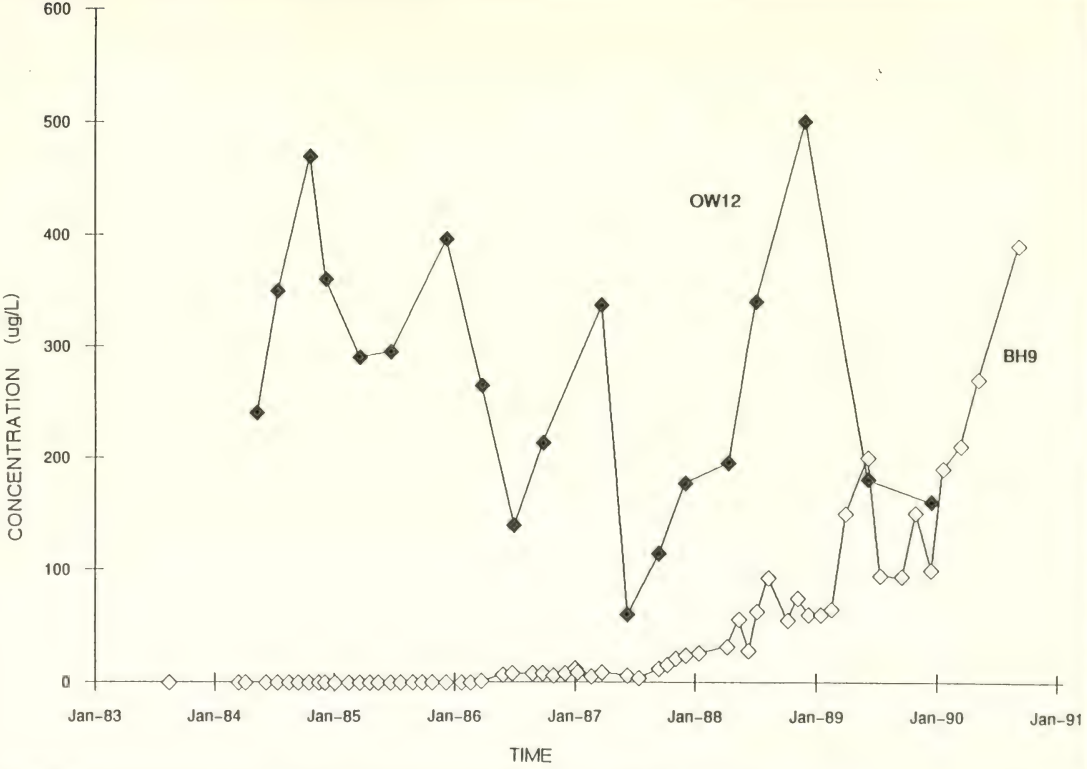
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

SCALE 1:5,000



PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

FIGURE **D6**
TOLUENE CONCENTRATION VERSUS TIME
FOR SELECTED WELLS

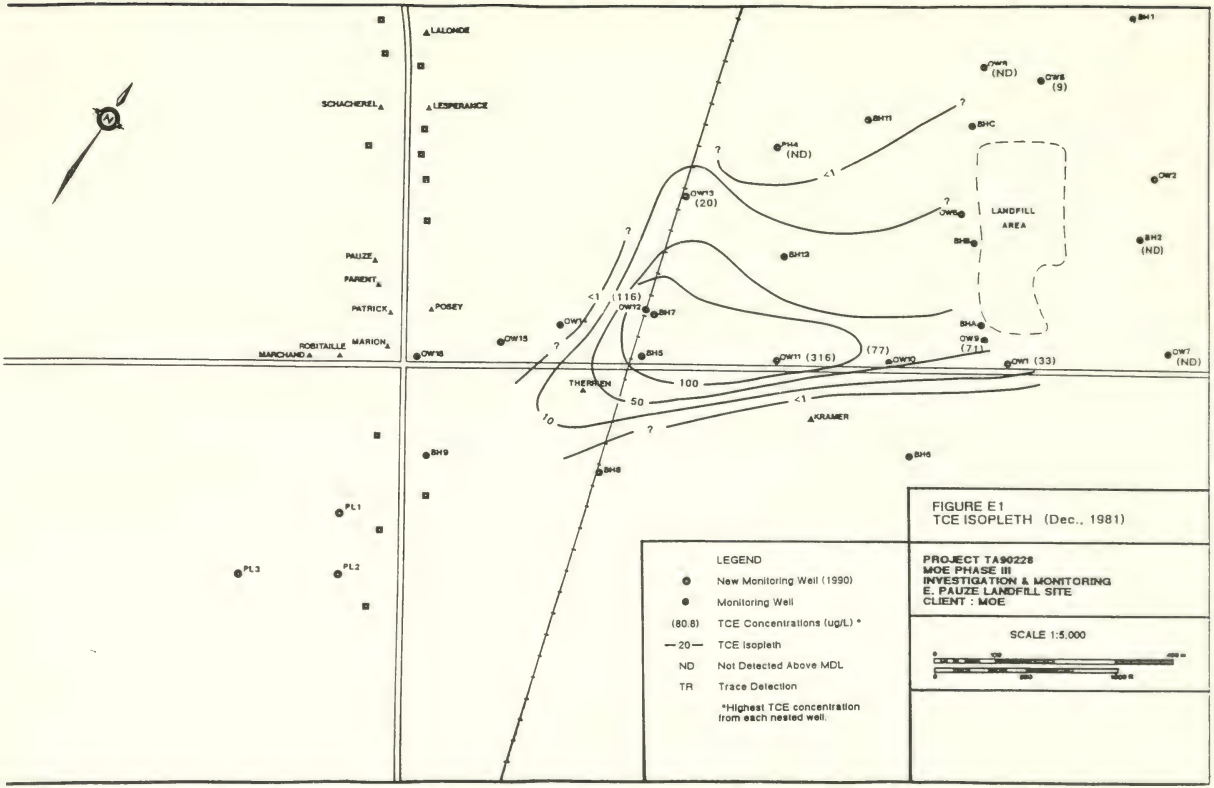


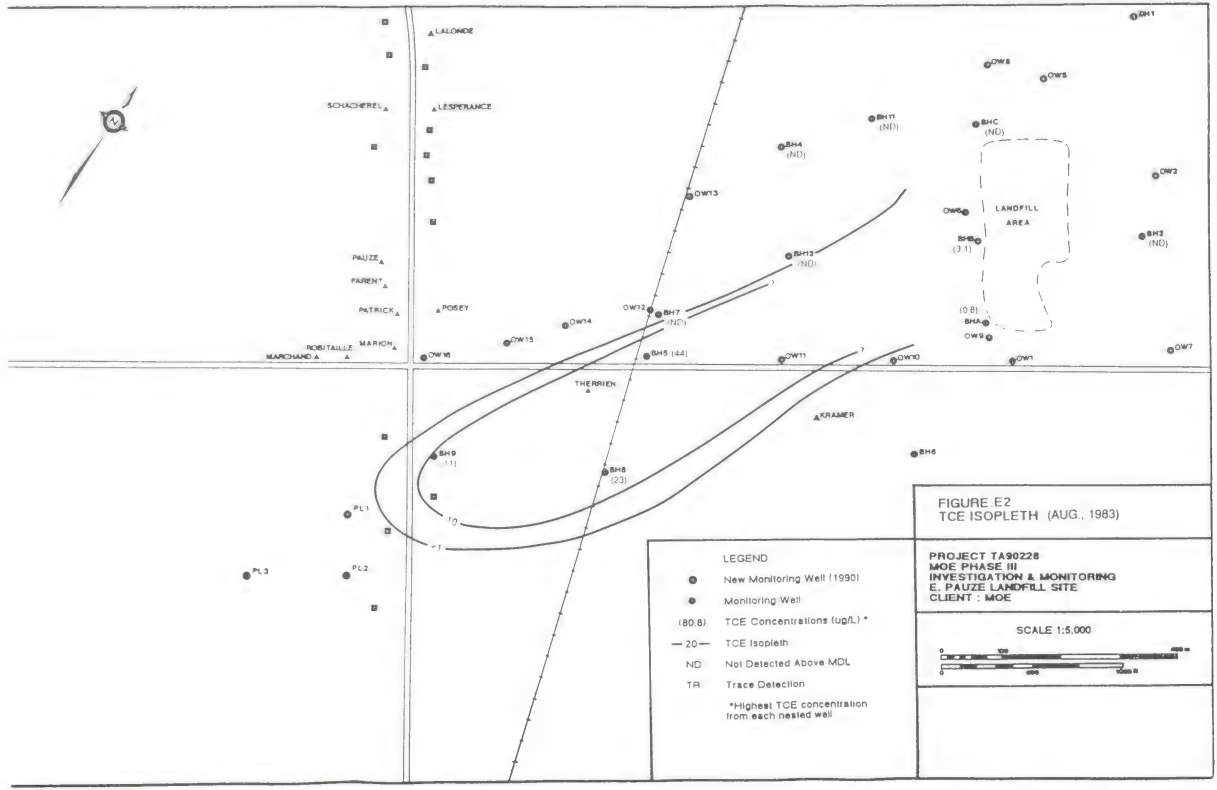
PROJECT TA90228
MOE Phase III
Investigation and Monitoring
E. Pauze Landfill Site
Client : MOE

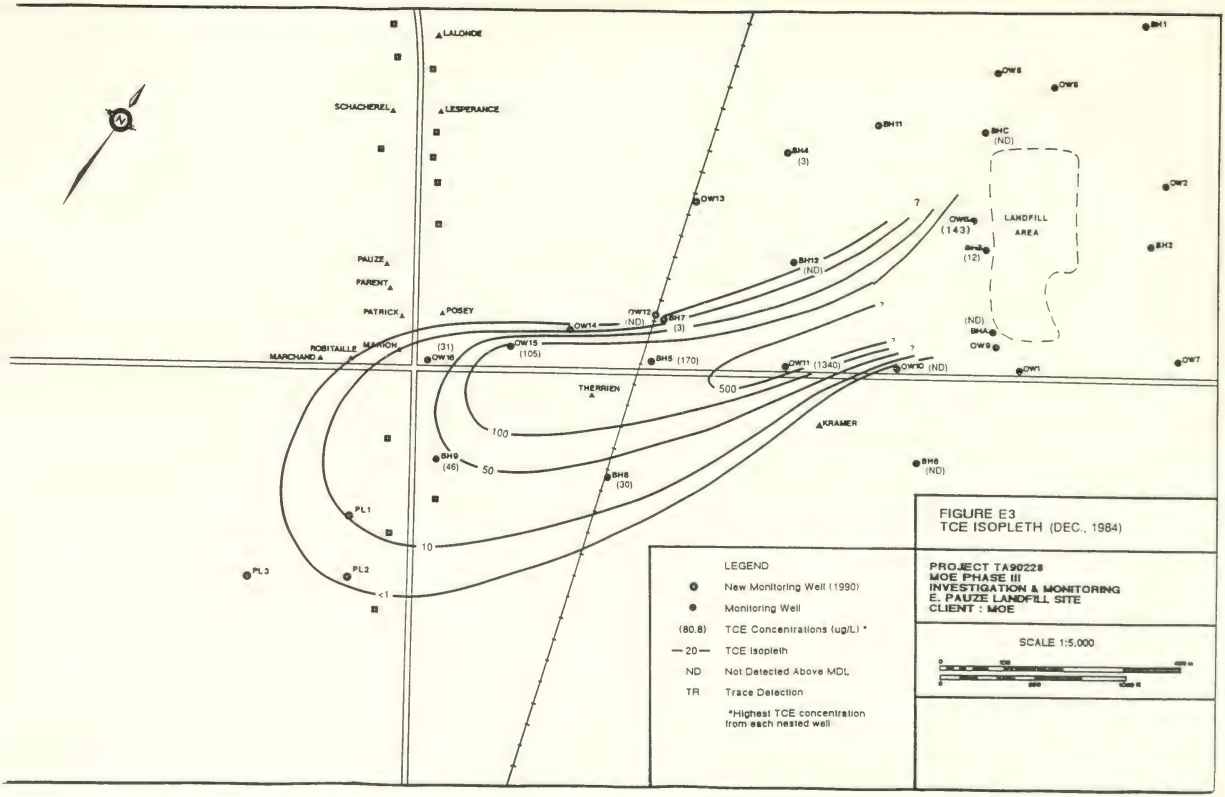
FIGURE D7
TOLUENE CONCENTRATION VERSUS TIME
FOR OW12 and BH9

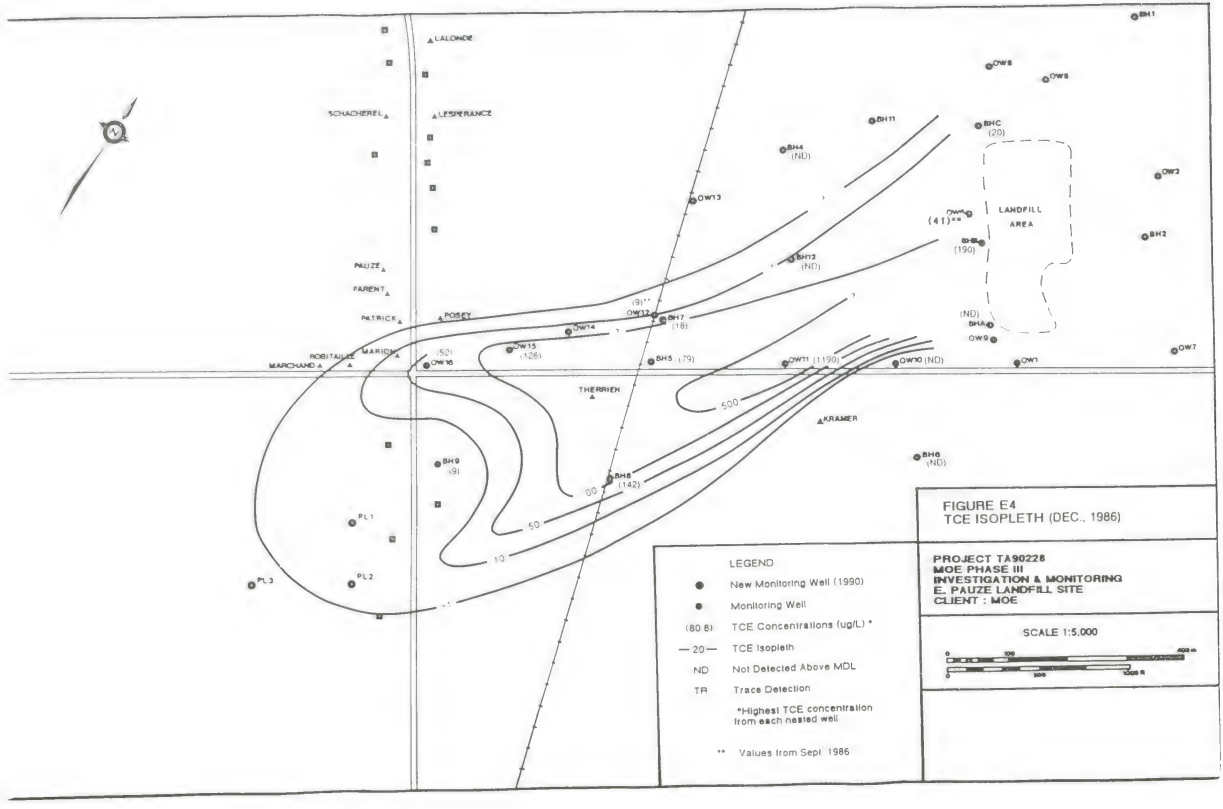
APPENDIX E

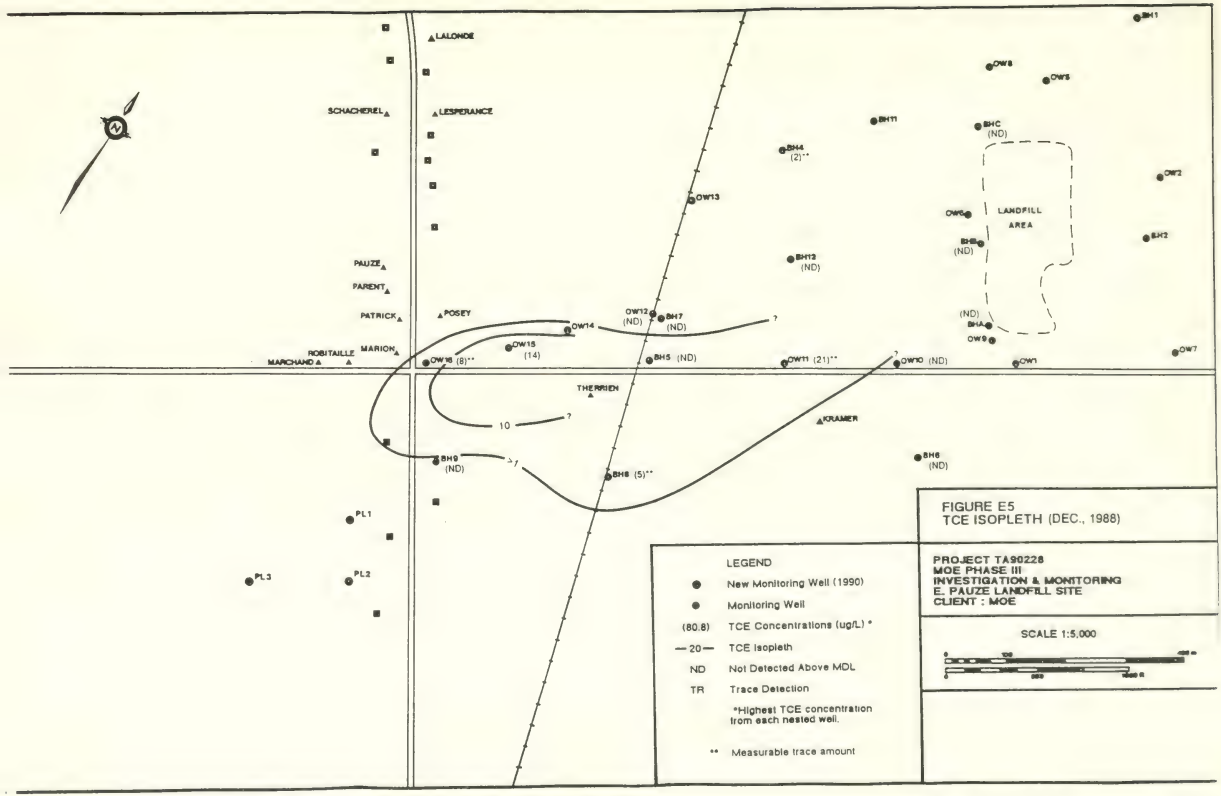
TCE ISOPLETHS


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2 (ND)
BH3
BH4 (ND)
BH5
BH6
BH7
BH8
BH9
BH10
BH11
BH12
BHA
BHB
BHC
OW1 (33)
OW2
OW3 (20)
OW4
OW5 (9)
OW6
OW7 (ND)
OW8 (ND)
OW9 (71)
OW10 (77)
OW11 (316)
OW12 (116)
OW13
OW14
OW15
OW16
PL1
PL2
PL3
100
50
10
<1
?
FIGURE E1
TCE ISOPLETH (Dec., 1981)
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) TCE Concentrations (ug/L) *
— 20 — TCE Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest TCE concentration from each nested well.
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
OW8
OW5
BH1 (ND)
BHC (ND)
BH4 (ND)
OW13
OW2
OW6
BH3 (ND)
BH2 (3.1)
BH12 (ND)
OW12
BH7 (ND)
OW14
OW15
OW16
BH5 (44)
OW11
OW10
OW1
OW7
(0.8) BHA
OW9
BH9 (11)
BH8 (23)
BH6
PL1
PL2
PL3
10
1
FIGURE E2
TCE ISOPLETH (AUG., 1983)
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) TCE Concentrations (ug/L) *
20 TCE Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest TCE concentration from each nested well
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHERIEL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARCHAND
MANION
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3 (12)
BH4 (3)
BH5 (170)
BH6 (ND)
BH7 (3)
BH8 (30)
BH9 (46)
BH10 (ND)
BH11
BH12 (ND)
BH13
BHA (ND)
BHB
BHC (ND)
OW1
OW2
OW3 (143)
OW5
OW6
OW7
OW8
OW9
OW10 (ND)
OW11 (1340)
OW12 (ND)
OW13
OW14
OW15 (105)
OW16 (31)
PL1
PL2
PL3
500
100
50
10
<1
?
FIGURE E3
TCE ISOPLETH (DEC., 1984)
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) TCE Concentrations (ug/L) *
— 20 — TCE Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest TCE concentration from each nested well
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
L'ESPERANCE
SCHACHERER
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARION
MARCHAND
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3 (190)
BH4 (ND)
BH5 (79)
BH6 (142)
BH7 (18)
BH8 (ND)
BH9 (9)
BH10 (ND)
BH11
BH12 (ND)
BHC (20)
OW1
OW2
OW4 (41)**
OW5
OW6
OW7
OW8
OW9
OW10 (ND)
OW11 (1190)
OW12 (9)**
OW13
OW14
OW15 (126)
OW16 (52)
PL1
PL2
PL3
500
100
50
10
1
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.6) TCE Concentrations (ug/L) *
— 20 — TCE Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest TCE concentration from each nested well
** Values from Sept 1986
FIGURE E4
TCE ISOPLETH (DEC., 1986)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000


LALONDE
LESPERANCE
SCHACHEREL
PAUZE
PARENT
PATRICK
POSEY
ROBITAILLE
MARCHAND
MARION
THERRIEN
KRAMER
LANDFILL AREA
BH1
BH2
BH3 (ND)
BH4 (2)**
BH5 (ND)
BH6 (ND)
BH7 (ND)
BH8 (5)**
BH9 (ND)
BH10 (ND)
BH11
BH12 (ND)
BH13
BH14 (ND)
OW1
OW2
OW3
OW4
OW5
OW6
OW7
OW8
OW9
OW10 (ND)
OW11 (21)**
OW12 (ND)
OW13
OW14
OW15 (14)
OW16 (8)**
PL1
PL2
PL3
10
?
FIGURE E5
TCE ISOPLETH (DEC., 1988)
PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE
SCALE 1:5,000
LEGEND
New Monitoring Well (1990)
Monitoring Well
(80.8) TCE Concentrations (ug/L) *
20 TCE Isopleth
ND Not Detected Above MDL
TR Trace Detection
*Highest TCE concentration from each nested well.
** Measurable trace amount

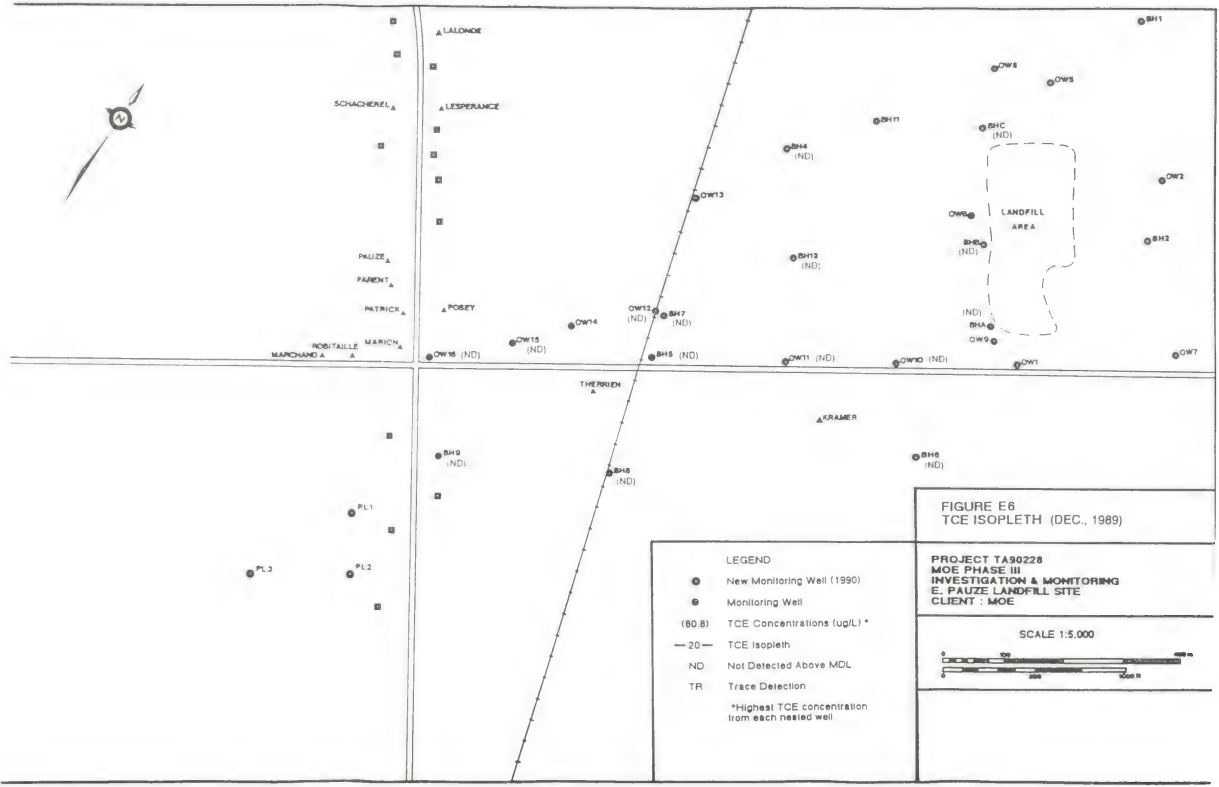


FIGURE E6
TCE ISOPLETH (DEC., 1989)

LEGEND

⊕	New Monitoring Well (1990)
⊕	Monitoring Well
(80.8)	TCE Concentrations (ug/L) *
— 20 —	TCE Isopleth
ND	Not Detected Above MDL
TR	Trace Detection

*Highest TCE concentration from each nested well

PROJECT TA90228
MOE PHASE III
INVESTIGATION & MONITORING
E. PAUZE LANDFILL SITE
CLIENT : MOE

SCALE 1:5,000

APPENDIX F

1990 WELL LOGS

Terraqua Investigations Ltd. | BOREHOLE / WELL NO.: PL1

PROJECT: PAUZE LANDFILL | CLIENT: MOE

PROJECT NO.: TA90228 | DATE INSTALLED: JULY 27, 1990

DRILLING METHOD: 8" Diameter Mud Rotary | TERRAQUA SUPERVISOR: S. Anderson

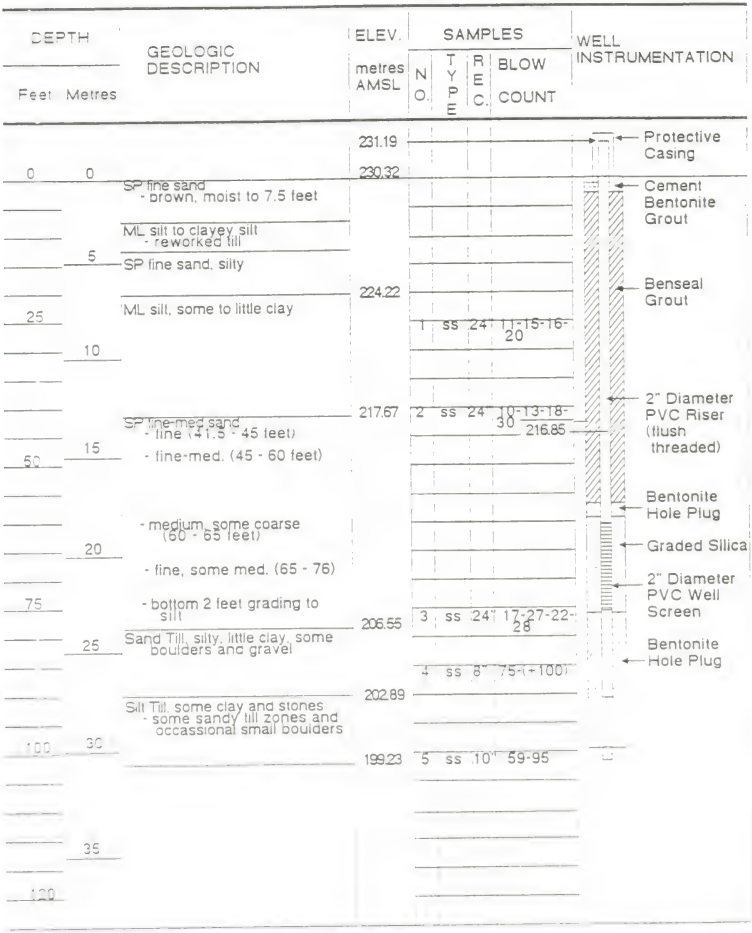
DEPTH Feet	DEPTH Metres	GEOLOGIC DESCRIPTION	ELEV. metres AMSL	SAMPLES NO.	TYPE	REC.	BLOW COUNT	WELL INSTRUMENTATION
			231.14					← Protective Casing
0	0		230.24					
		SP fine sand - brown to 4 feet - grey/brown 4-8 feet, moist - grey wet 8-10 feet						← Cement Bentonite Grout
		SP & ML fine sand and silt - interlayered						
	5		225.67					
		ML clayey silt, little sand						← Benseal Grout
25			222.67					
		ML silt, little clay						
	10							
								← 2" Diameter PVC Riser (flush threaded)
			218.34					
			216.52	1	ss	24"	7-8-9-13	
	15							
50		SP silty fine sand - some interlayered silt layers (45 - 65 feet)						
	20							
		- coarse sand seams (65 - 95 feet)						
75				2	ss	12"	38-(+50)	← Bentonite Hole Plug/ Some Cave
	25							
								← Graded Silica
								← 2" Diameter PVC Well Screen
			201.28					
100	30	Silt Till, some clay and stones		3	ss	10"	27-(+100)	
								← Bentonite Hole Plug
	35							← Benseal Grout
120								
			191.53	4	ss	8"	39-(+100)	

Terraqua Investigations Ltd. BOREHOLE / WELL NO.: PL2

PROJECT: PAUZE LANDFILL CLIENT: MOE

PROJECT NO.: TA90228 DATE INSTALLED: JULY 31, 1990

DRILLING METHOD: 8" Diameter Mud Rotary TERRAQUA SUPERVISOR: S. Anderson



Terraqua Investigations Ltd. | BOREHOLE / WELL NO.: PL3

PROJECT: PAUZE LANDFILL | CLIENT: MOE

PROJECT NO.: TA90228 | DATE INSTALLED: AUGUST 2, 1990

DRILLING METHOD: 8" Diameter Mud Rotary | TERRAQUA SUPERVISOR: S. Anderson

DEPTH Feet	DEPTH Metres	GEOLOGIC DESCRIPTION	ELEV. metres AMSL	SAMPLES NO.	TYPE	REC.	BLOW COUNT	WELL INSTRUMENTATION
			230.32					Protective Casing
0	0		229.67					
		SP & ML fine sand and silt - brown, interlayered						Cement Bentonite Grout
		- mainly fine sand (10-15 feet)						
	5		225.65					
		ML silt, moist, grey/brown						Benseal Grout
25								
	10			1	ss	24		2" Diameter PVC Riser (flush threaded)
	15						215.08	
50		SP very fine sand, silty, grey - some silt layers	214.43	2	ss	24		
	20							
75								
	25							Graded Silica
				3	ss	24		2" Diameter PVC Well Screen
			201.17					
		Silt Till, some clay and stones - some sandy till zones and occassional small boulders						Bentonite Hole Plug
100	30		198.58	4	ss	10	73-(+100)	
	35							
120								

APPENDIX G

HYD-ENG GEOPHYSICS INC.

WELL LOGGING REPORT

Job. TH228.

RECEIVED AUG 14 1990

Hyd-Eng GEOPHYSICS INC.

FILE COPY

FILE COPY

Mr. Sandy Anderson, P. Eng.,
Terraqua Investigations,
41 Princess Street East,
Waterloo, Ontario,
N2J 2H6

August 9, 1990

Dear Mr. Anderson;

This letter is to report the results of the downhole geophysics survey at the Pauze Landfill near Midland, Ontario. Hyd-Eng Geophysics Inc. was retained to log 3 boreholes and interpret the results. Field work was completed on August 1st, 1990.

Both natural gamma and apparent conductivity logs were collected at 2 of the installations (PL-1 and PL-2). An additional gamma log was recorded for BH-9 installed earlier by Gartner Lee Limited.

The natural gamma log gives a measure of the gamma level energy emitted naturally by the subsurface in counts per second (cps). Potassium, uranium and thorium all emit gamma radiation. However, most commonly it is the potassium bound in clay minerals that the probe is responding to. The gamma levels can, therefore, be related to clay content. The apparent conductivity is measured using the principles of electromagnetic (EM) induction. Output is in readings of millisiemens per metre (mS/m). The instrument is focussed so that the measuring radius is from approximately [redacted] to 1 metre around the probe.

[redacted] ct #: 224

[redacted] Item #: C-008

In providing the interpretations of the logs, a few additional points were taken into consideration.

Generally the bulk apparent conductivity of subsurface materials increases with increasing clay content, porewater conductivity and water content. Under uncontaminated conditions, the conductivity and gamma logs are subparallel. For units in which the porewater conductivity is anomalously high, the apparent conductivity log will indicate higher levels than would be expected based on the gamma log. Thus by cross correlating the gamma and conductivity logs, a qualitative estimate of porewater conductance is made.

Another aspect in interpreting these logs was the presence of grout throughout much of the boreholes. The benseal grout used in the installations appears to have significantly raised the gamma count level. This has the effect of decreasing the sensitivity of the log to changes in geology. Secondly, because the grout may have been mixed unevenly in the borehole annulus, variations in response may relate to grout concentration. However, the apparent conductivity log is focussed to minimize borehole effects. Therefore, where significant changes occur in the conductivity log which relate to changes in the gamma log, it is assumed that this is due to a change in geology. Contacts have been placed on the interpretations with this in mind. For these reasons, only a broad scale textural classification has been included in the interpretation.

The results of the survey are presented in the following three figures. Each diagram includes the natural gamma and apparent conductivity logs, interpreted lithologic contacts and anomalous porewater conductivity as well as the geology and a schematic of the piezometer installation at each site where available.

Hyd-Eng GEOPHYSICS INC.

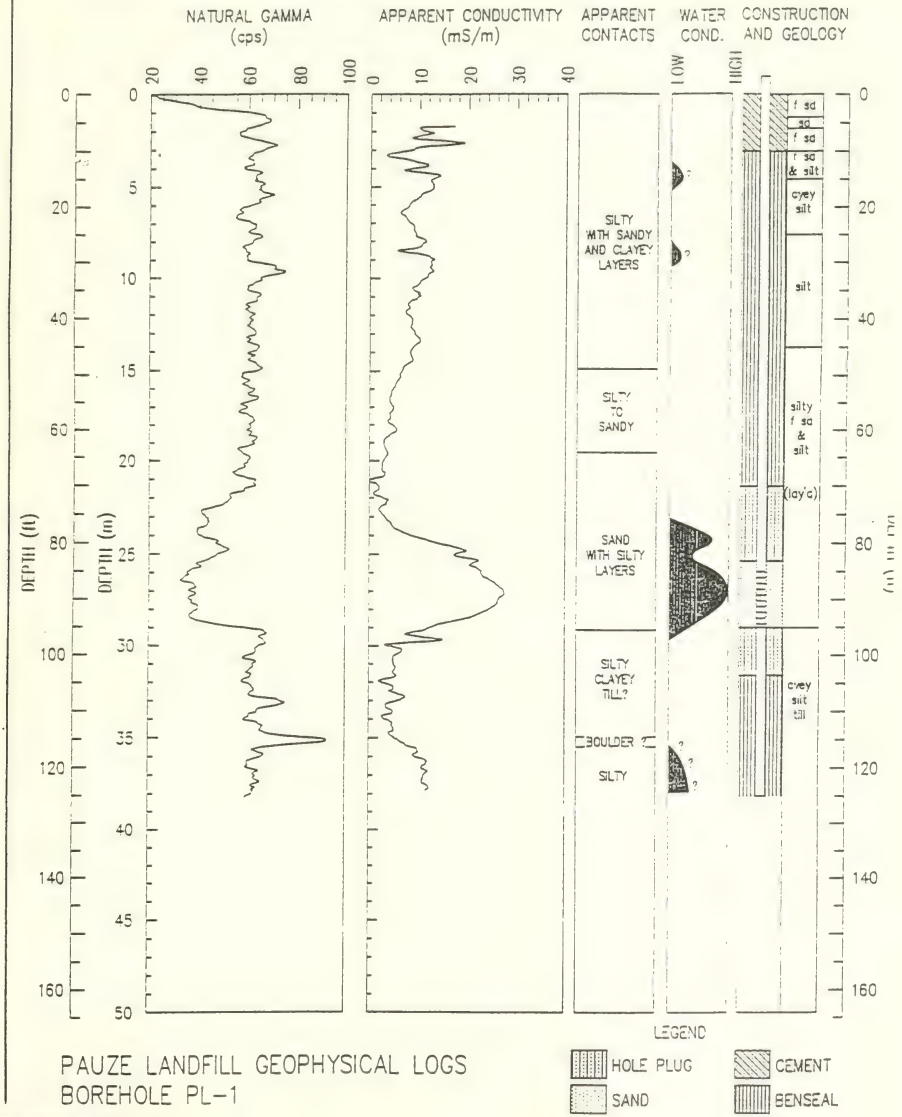
In the water conductivity column on the logs for PL-1 and PL-2, the small anomalous zones in the upper portions of the logs have been question marked. While the data indicates anomalously high porewater conductivities for these zones, the effect is small and could be attributed to variable water content. The lack of correlation between the conductivity and gamma logs at the bottom of PL-1 is also indicative of anomalous high porewater conductivity. However, this could also be attributable (in part or in whole) to a change in the stratigraphy at approximately 35 metres depth from till to silty sand. Tills can have lower apparent conductivities than other sediments due to poor sorting and subsequent low interconected water content.

I trust this information will be useful to you in your investigation. If any questions arise, please do not hesitate to call.

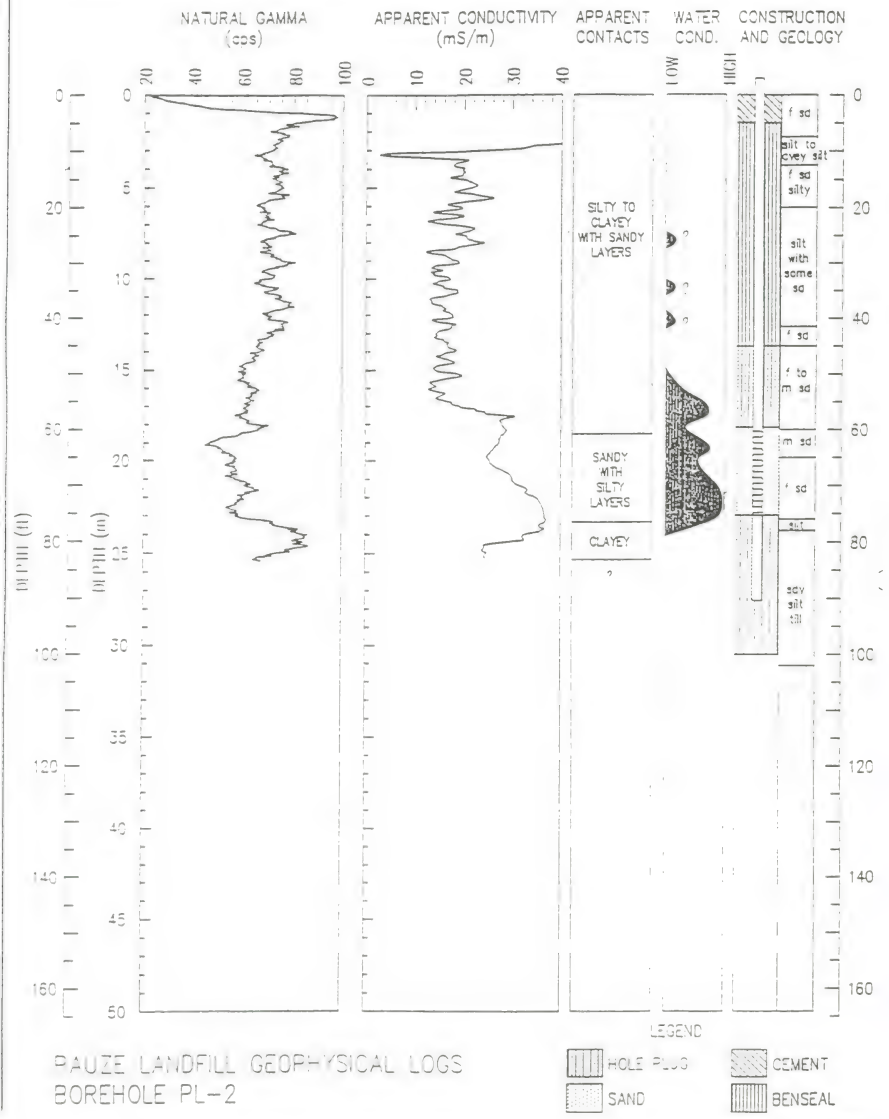
Yours Sincerely,

Mark E. Monier-Williams, M.Sc.,
Geotechnical Geophysicist.

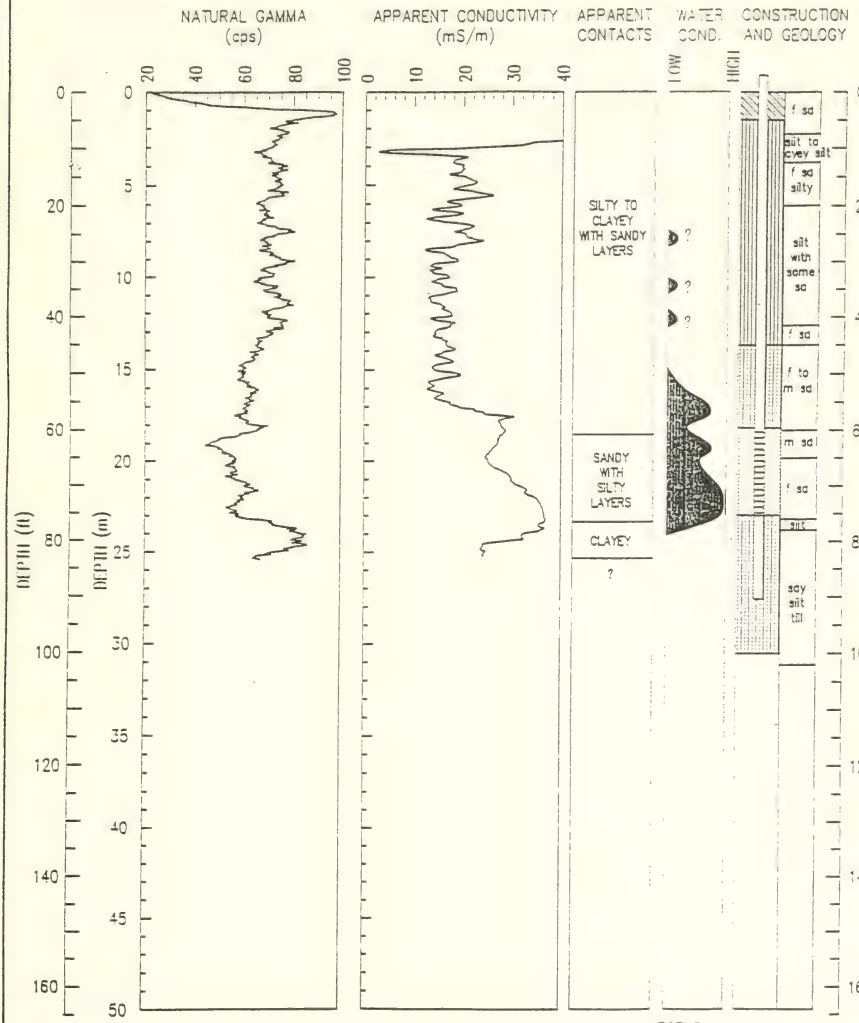
PAUZE LANDFILL GEOPHYSICAL LOGS
BOREHOLE PL-1



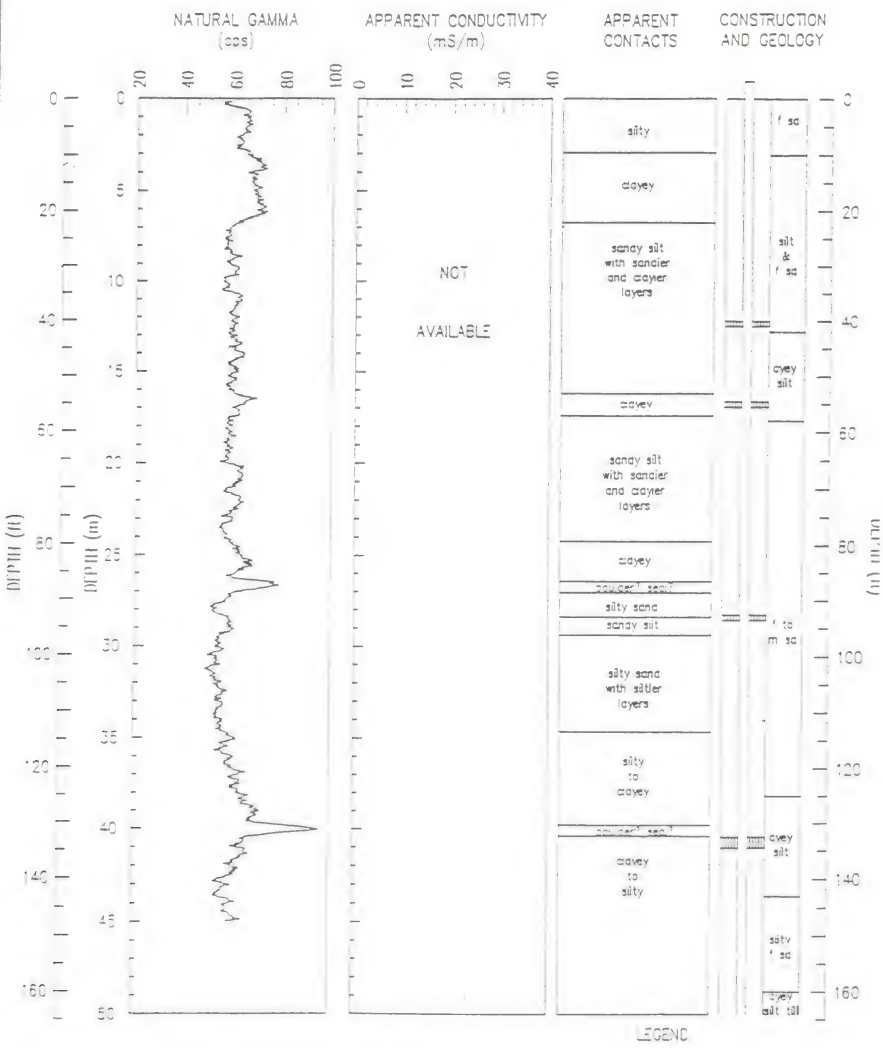
PAUZE LANDFILL GEOPHYSICAL LOGS
BOREHOLE PL-1



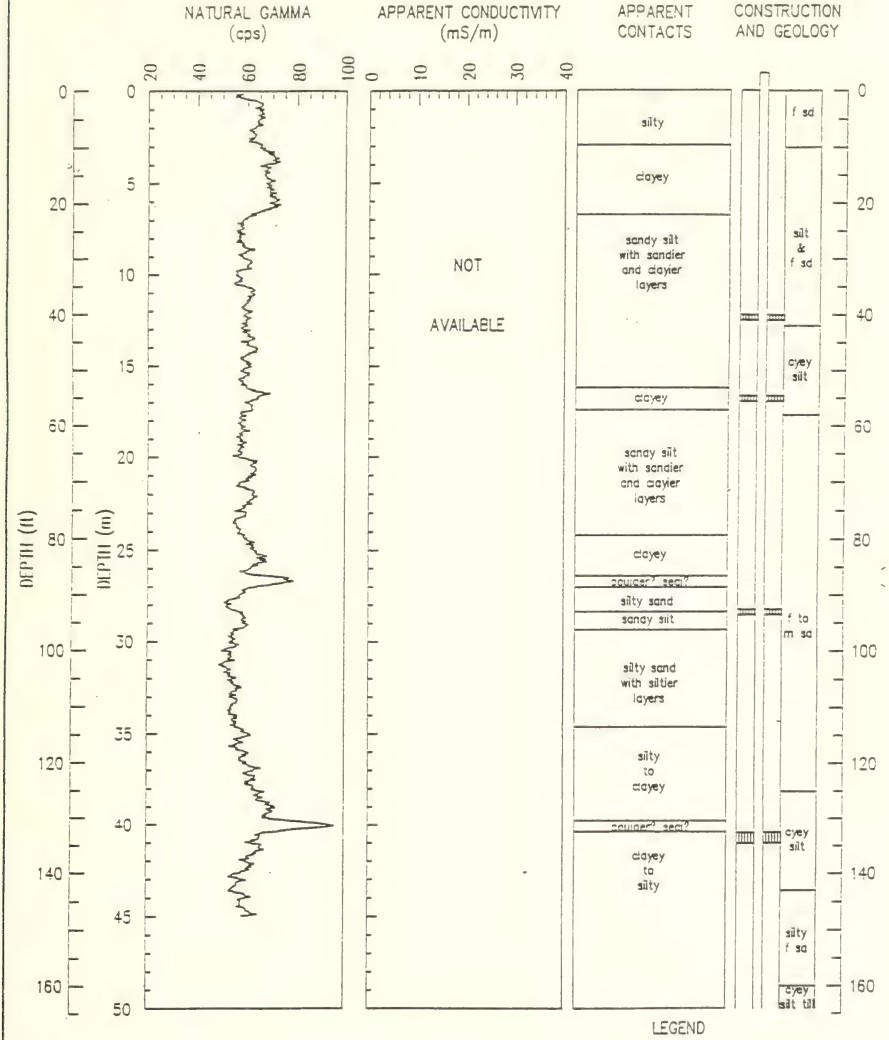
PAUZE LANDFILL GEOPHYSICAL LOGS
BOREHOLE PL-2



PAUZE LANDFILL GEOPHYSICAL LOGS
BOREHOLE PL-2



PAUZE LANDFILL GEOPHYSICAL LOGS
BOREHOLE GL-BH9

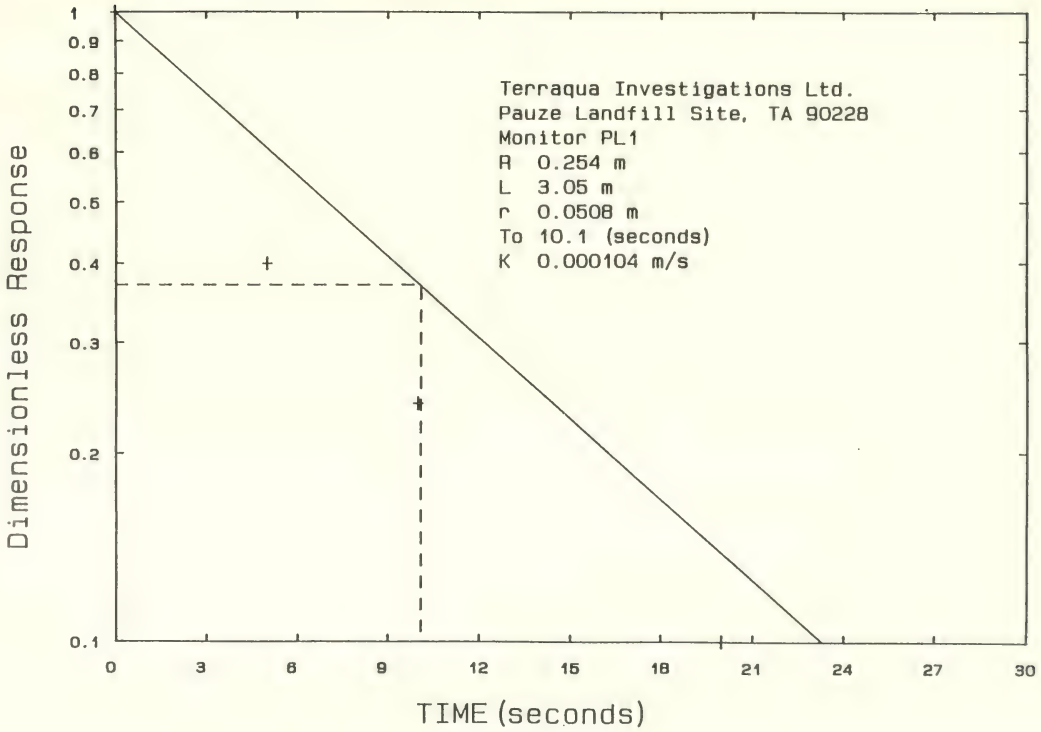


PAUZE LANDFILL GEOPHYSICAL LOGS
BOREHOLE GL-BH9

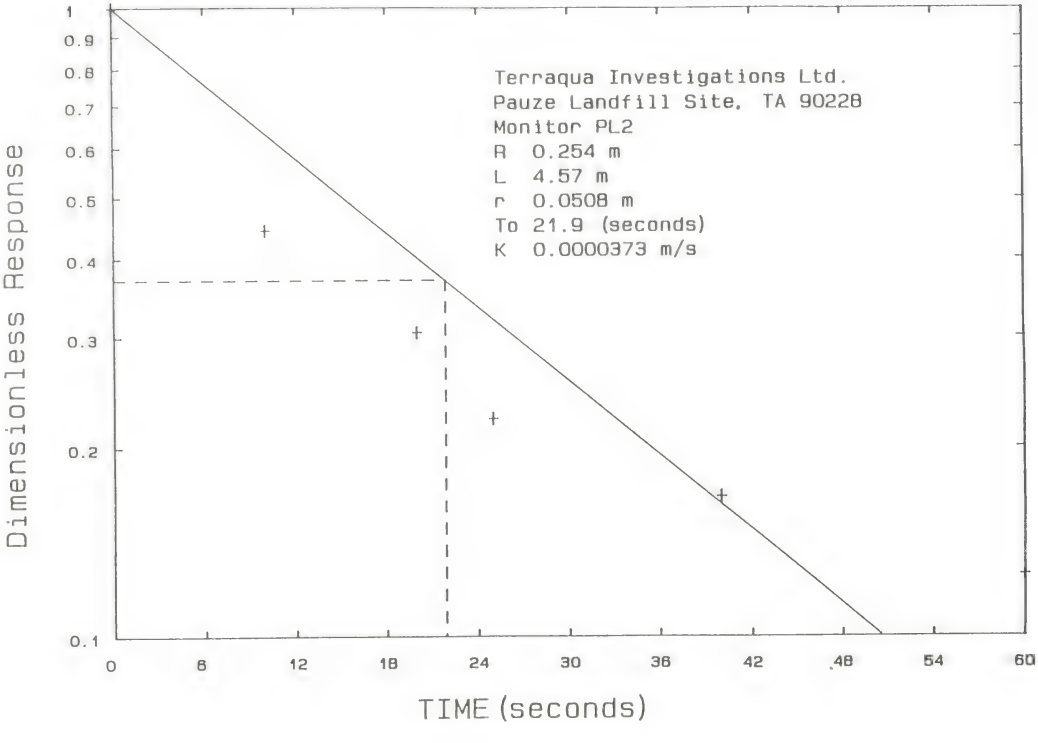
APPENDIX H

WELL RESPONSE TEST RESULTS

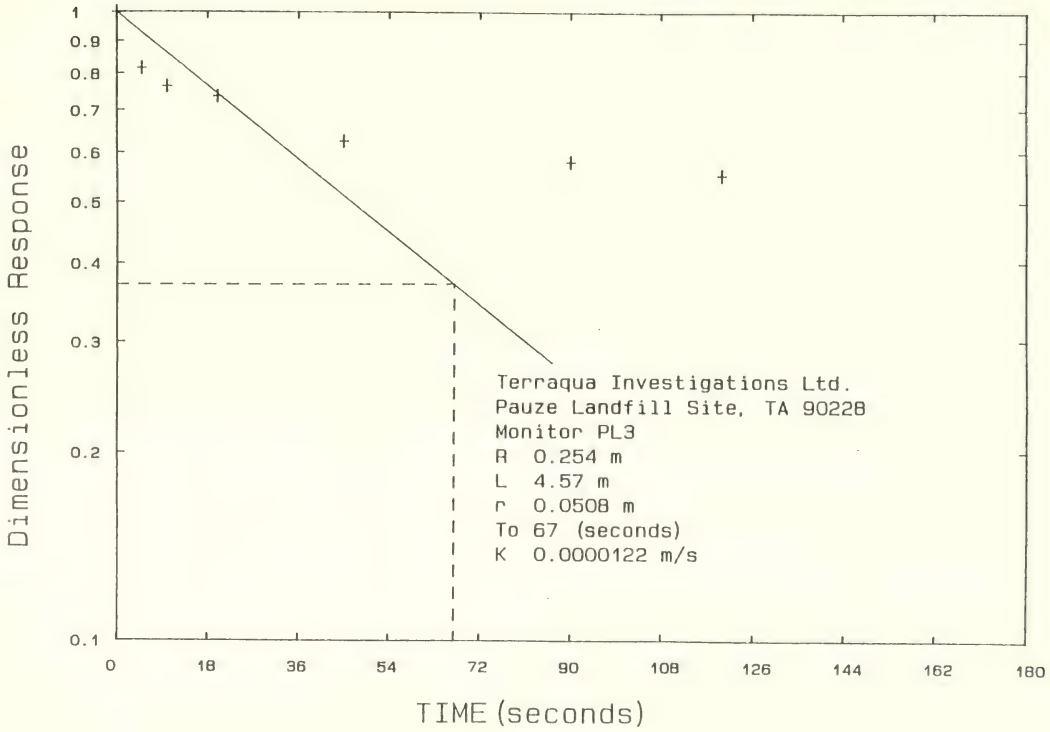
RESPONSE TEST ANALYSIS



RESPONSE TEST ANALYSIS



RESPONSE TEST ANALYSIS.



APPENDIX I

1990 LABORATORY ANALYTICAL DATA

IVIROCLEAN LONDON • TORONTO
NIT OF LAVALIN ENGINEERS INC.
LEATHORNE STREET, LONDON, ONTARIO, CANADA N5Z 3M7 (519) 686 7550

Att: Sandy Anderson

OJECT NO: 43120-A7-050000 CLIENT: Terraqua Investigations Ltd. Waterloo SOURCE: Water Samples

ALYTICAL RESULTS – Milligrams per litre (except for pH values and where stated) Your Ref No. TA 90228

MPLE O.	DATE AND TIME TAKEN	DATE ANALYSIS COMMENCED	DESCRIPTION	pH Value	Total Kjeldahl Nitrogen N	Nitrate NO_3	Nitrite NO_2	Conductivity us/cm	Sulphate SO_4	Alkalinity $CaCO_3$	Bromide Br	Chloride Cl
14052	15 Aug 90	21 Aug 90	S1	6.8	<0.01	0.13	0.045	1030	4.4	850	<1	41
14053	"	"	S2	7.3	<0.01	0.36	0.024	724	9.7	530	<1	18
14054	"	"	S3	8.1	<0.01	0.64	0.035	286	17	456	<1	6
14055	"	"	S4	-	<0.01	-	-	279	-	-	-	-
14056	"	"	S5	5.2	<0.01	0.08	0.011	<5	<1	2	<1	<1

NOTE: Sample 90/14055 - S4 - Contained Much Suspended Solids

FILE COPY

/IROCLEAN LONDON • TORONTO
IT OF LAVALIN ENGINEERS INC
LEATHORNE STREET, LONDON, ONTARIO, CANADA N5Z 3M7 (519) 686 7558

IECT NO. 43120-AZ-050000 CLIENT Terraqua Investigations Ltd. Waterloo SOURCE: Water Samples

LYTICAL RESULTS — Milligrams per litre (except for pH values and where stated)

PLE)	DATE AND TIME TAKEN	DATE ANALYSIS COMMENCED	DESCRIPTION	Total Hardness $CaCO_3$	Phenol ug/L	Calcium Ca	Iron Fe	Magnesium Mg	Potassium K	Sodium Na		
1052	15 Aug 90	21 Aug 90	S1	264	39	209	15.9	43.4	2.80	9.64		
1053	"	"	S2	172	<1	166	4.16	39.7	2.00	30.8		
1054	"	"	S3	158	<1	37.3	68.2	7.23	1.50	15.9		
1055	"	"	S4	-	<1	46.3	-	8.35	-	3.77		
1056	"	"	S5	<1	7	0.33	0.06	<0.02	0.09	0.79		

ENVIROCLEAN
A UNIT OF LAVALIN ENGINEERS INC.
921 Leathorne Street, London, Ontario N5Z 3M7
(519) 686-7558 Fax: (519) 686-6374

ANALYTICAL REPORT

Volatile Analysis by Purge and Trap GC/MS, Full Scan

Client: Terraqua Investigation (Waterloo)
Project No.: 43120-A7-050000

Date Received: August 15,1990
Date Analysis Started: August 21,1990
Date Reported: August 29,1990

Sample Description: 90/14052:S1
90/14053:S2
90/14054:S3
90/14055:S4
90/14056:S5

Matrix: Water

Compound	MDL (ug/L)	90/14052 (ug/L)	90/14053 (ug/L)	90/14054 (ug/L)	90/14055 (ug/L)	90/14056 (ug/L)
Chloromethane	0.2	ND	ND	ND	ND	ND
Vinyl Chloride	0.2	25	45	9	ND	ND
Bromomethane	0.2	ND	ND	ND	ND	ND
Chloroethane	0.2	5	5	ND	ND	ND
Acrolein	1.0	ND	ND	ND	ND	ND
Trichlorofluoromethane	0.2	ND	ND	ND	ND	0.7
Acrylonitrile	0.5	ND	ND	ND	ND	ND
1,1-Dichloroethene	0.2	0.6(ND)	0.7(ND)	1(ND)	ND	ND
Dichloromethane	0.8	ND	ND	6(ND)	ND	ND
t-1,2-Dichloroethene	0.2	ND	ND	ND	ND	ND
1,1-Dichloroethane	0.2	46	18	5	ND	ND
Methyl Ethyl Ketone	0.5	100	ND	ND	ND	ND
Chlorobromomethane	0.2	ND	ND	ND	ND	ND
Chloroform	0.2	ND	ND	ND	ND	ND
1,2-Dichloroethane	0.2	ND	0.9(ND)	1.5(ND)	ND	ND
1,1,1-Trichloroethane	0.2	8	4	7	ND	ND
Benzene	0.2	5	2	ND	ND	ND
Carbon Tetrachloride	0.2	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.2	ND	ND	ND	ND	ND
Bromodichloromethane	0.4	ND	ND	ND	ND	ND
Trichloroethene	0.5	26	52	53	ND	ND
Cis-1,3-Dichloropropene	1.0	ND	ND	ND	ND	ND
tr-1,3-Dichloropropene	0.2	ND	ND	ND	ND	ND
1,1,2-trichloroethane	0.2	4	2	2	ND	ND
Toluene	0.2	44	ND	ND	0.6	0.3
Chlorodibromomethane	0.2	ND	ND	ND	ND	ND
1,2-Dibromoethane	0.2	ND	ND	ND	ND	ND
Tetrachloroethene	0.2	3	7	ND	0.2	ND
Chlorobenzene	0.2	ND	ND	ND	ND	ND

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ANALYTICAL REPORT

Volatile Analysis by Purge and Trap GC/MS, Full Scan

Client: Terraqua Investigation (Waterloo)
Project No.: 43120-A7-050000

Date Received: August 15,1990
Date Analysis Started: August 21,1990
Date Reported: August 29,1990

Sample Description: 90/14052:S1
90/14053:S2
90/14054:S3
90/14055:S4
90/14056:S5

Matrix: Water

Compound	MDL (ug/L)	90/14052 (ug/L)	90/14053 (ug/L)	90/14054 (ug/L)	90/14055 (ug/L)	90/14056 (ug/L)
Ethylbenzene	0.2	1.6(ND)	ND	ND	0.2	ND
m&p-Xylenes	0.2	1(ND)	ND	ND	ND	ND
Bromoform	0.2	ND	ND	ND	ND	ND
Styrene	0.5	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.3	ND	ND	ND	ND	ND
o-Xylene	0.2	1(ND)	ND	ND	ND	ND
1,2-Dichlorobenzene	0.5	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	0.5	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	1.0	ND	ND	ND	ND	ND

ND-NOT DETECTED
MDL-METHOD DETECTION LIMIT

NOTE:For sample 90/14052 multiply the listed MDL values by 14.
NOTE:For sample 90/14053 multiply the listed MDL values by 11.
NOTE:For sample 90/14054 multiply the listed MDL values by 11.

W.M. Neaves, MSc., C.Chem.

T4228

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ANALYTICAL REPORT

Reported: 90- 9-28 Page:

Client: TERRACON INVESTIGATIONS LTD. WATERLOO

Project Number: 50901/50902 P.O.:

Attention: MS Sandy Anderson Date Received: 90- 9-06
Client Ref. #: 90228 "PAUZE" Sample Type: Liquid

Sample #	Analytical Parameter	MDL	Result	Units	Comment
90-4018194	Sample Description: SW 6 #90228		Date Sampled: 90- 9-05 Time Sampled:		
	pH Value	0.01	7.91	pH Units	
	Total Kjeldahl Nitrogen N	0.05	1.78	mg/L	
	Nitrate	0.01	0.01	mg/L	
	Nitrite	0.001	0.001	mg/L	
	Conductivity	1.0	2110	uS/cm	
	Sulphate SO4	0.5	ND	mg/L	
	Alkalinity CaCO3	2.0	1130	mg/L	
	Chloride Cl	0.1	ND	mg/L	
	Chloride Cl	1	1010	mg/L	
	Total Hardness as EDTA	1.0	1040	mg/L	
	Phenol 4-AAP only	0.01	0.01	mg/L	
	Calcium Ca	0.1	201	mg/L	
	Iron Fe	0.02	0.14	mg/L	
	Magnesium Mg	0.1	71.6	mg/L	
	Potassium K	0.01	0.80	mg/L	
	Sodium Na	0.1	94.8	mg/L	

DL: Denotes Method Detections Limit
ND: Denotes Not Detected

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ANALYTICAL REPORT

Volatile Analysis by Purge and Trap GC/MS, Full Scan

Client: Terraqua Investigation

Date Received: September 6,1990
Date Analysis Started: September 6,1990
Date Reported: September 13,1990

Sample Description: GC/1819B:SN 6 #900209
GC/1819T:Travel Blank

Matrix: Water

Compound	MDL ug/L	GC/1819B ug/L	GC/1819T ug/L
Chloromethane	0.5	<0.5	<0.5
Vinyl Chloride	0.5	<0.5	<0.5
Bromomethane	0.5	<0.5	<0.5
Chloroethane	0.5	45	<0.5
Acrolein	1.0	<1.0	<1.0
Trichlorofluoromethane	0.5	<0.5	<0.5
Acrylonitrile	1.0	<1.0	<1.0
1,1-Dichloroethene	0.5	<0.5	<0.5
Dichloromethane	0.5	<0.5	<0.5
trans-1,2-Dichloroethene	0.5	<0.5	<0.5
1,1-Dichloroethane	0.5	<0.5	<0.5
Methyl Ethyl Ketone	0.5	200	<0.5
2,2-Dichloropropane	0.5	<0.5	<0.5
Chloroform	0.5	<0.5	<0.5
1,2-Dichloroethane	0.5	<0.5	<0.5
1,1,1-Trichloroethane	0.5	<0.5	<0.5
Benzene	0.5	1	<0.5
Carbon Tetrachloride	0.5	<0.5	<0.5
1,2-Dichloropropane	0.5	<0.5	<0.5
Bromodichloromethane	0.5	<0.5	<0.5
Trichloroethene	0.5	<0.5	<0.5
cis-1,3-Dichloropropene	0.5	<0.5	<0.5
trans-1,3-Dichloropropene	0.5	<0.5	<0.5
1,1,2-Trichloroethane	0.5	<0.5	<0.5
Toluene	0.5	88	<0.5
Chlorodibromomethane	0.5	<0.5	<0.5
1,2-Dibromoethane	0.5	<0.5	<0.5
Tetrachloroethene	0.5	<0.5	<0.5

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ANALYTICAL REPORT

Volatile Analysis by Purge and Trap GC/MS, Full Scan

Client: Terradua Investigation

Date Received: September 6,1990
Date Analysis Started: September 6,1990
Date Reported: September 13,1990

Sample Description: 90/15196:SN 6 #90229
90/15197:Travel Blank

Matrix: Water

Compound	MDL (ug/L)	90/15196 (ug/L)	90/15197 (ug/L)
Chlorobenzene	0.2	ND	ND
Ethylbenzene	0.2	30	ND
m&p-Xylenes	0.2	30	ND
Bromoform	0.2	ND	ND
Styrene	0.5	ND	ND
1,1,2,2-Tetrachloroethane	0.3	ND	ND
o-Xylene	0.2	10	ND
1,2-Dichlorobenzene	0.5	ND	ND
1,3-Dichlorobenzene	0.5	ND	ND
1,4-Dichlorobenzene	1.0	ND	ND

ND=NOT DETECTED
MDL=METHOD DETECTION LIMIT

NOTE:For sample 90/15196 multiply the listed MDL values by 40.

W.M. Neaves, MSc., C.Chem.